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Herbert Couper Wilson
1858-1940

By CURVIN H. GINGRICH

All persons who were readers of POPULAR ASTRONOMY in the interval from its beginning, in the year 1894, to the year 1926 will recall immediately the name Professor Herbert C. Wilson. For, during that entire period, his name appeared on the cover as associate editor or as editor. Since his retirement from active collegiate duties in 1926, his name has appeared in the magazine only occasionally in connection with articles contributed by him, and hence the more recent readers have not had the opportunity of becoming so well acquainted with him.

In order that his friends and associates of the earlier years may once more be reminded of him and possibly recall and relive, in memory, the experiences of by-gone days, and in order that the more recent members of the astronomical fraternity may learn of one who was an energetic and successful worker in their common field in his day, and finally, in order that there may be a record of the activities, accomplishments, and exceptional personal qualities of one who is eminently worthy of such record, this biographical sketch has been prepared.

Professor Wilson, for by that title he was familiarly known by students, colleagues, and fellow townsmen for more than half a century, held almost uninterrupted connection with Carleton College in one capacity or another from the time he entered the Preparatory Department as a student in 1872 until the time of his death on March 9, 1940. His lifespan may be regarded as one of the few bridges connecting the early days of the College with those of the present. In his youth he studied under the instruction of the masterful teachers who founded the College; in his prime he became one of the bulwarks of the College in its period of extensive growth in size and in importance; in his years of retirement he continued to shed his benign influence upon those who succeeded him.

Herbert C. Wilson was born in Lewiston, Minnesota, on October 24, 1858. He entered the Preparatory Department of Carleton College at Northfield, Minnesota, before he was fourteen years of age. He spent three years in this department before entering the Collegiate Department. He was one of four to enter the College as Freshmen in 1875, and one of three to be graduated in 1879. Herbert C. Wilson ranked highest in the entrance examinations given in 1875, and consequently he was awarded the Atkins scholarship prize in that year. The courses offered

in the College were quite definitely prescribed but he showed a leaning toward mathematics and astronomy, influenced, very likely, by the enthusiasm of Professor William W. Payne who was then in charge of the Department of Mathematics and Astronomy, and was engaged at that time in establishing the first observatory on the campus. Later Professor Payne was instrumental in the erection of the second and larger observatory, now known as the Goodsell Observatory.

A year, during which he was principal in the public school in Janesville, Minn., intervened between Herbert C. Wilson's graduation from College and his entering definitely the field of astronomy, which was to become his major interest during the remainder of his life. In the autumn of 1880 he began work at the Cincinnati Observatory, at Mt. Lookout, under the direction of Professor Ormond E. Stone. Herbert C. Wilson was one of a group of five men who worked at Cincinnati about that same time and later became prominent in astronomical work in various parts of this country. Herbert A. Howe, for many years the director of the Chamberlin Observatory of the University of Denver, and Winslow Upton, director of the Ladd Observatory, Brown University, had received the degree of Master of Arts there in 1877. Albert S. Flint, later of the Washburn Observatory, University of Wisconsin, had received the same degree in 1880, and Francis P. Leavenworth, later of the University of Minnesota, was a student there with him. Herbert C. Wilson was made an assistant for the year 1881-82, and, upon the resignation of the director at the end of that year, was made astronomer *pro tempore* and was in charge of the observatory until the new director, Dr. J. G. Porter, was appointed in 1884. He continued as assistant to Dr. Porter until June, 1886. At the conclusion of his work at Cincinnati he was granted the degree of Ph.D., the first degree of this rank to be granted by the University of Cincinnati. The fact of the conferring of this degree is recorded in the following sentence, "The Board of Directors, upon recommendation of the Faculty, conferred upon him the degree of Doctor of Philosophy for six years of faithful work at the University and his successful pursuit of post-graduate studies."

His astronomical work at Cincinnati was chiefly with the 11-inch telescope, observing double stars, comets, asteroids; he also made time observations with the 3-inch transit. The principal results of his work are found in three of the *Publications of the Cincinnati Observatory* as follows:

No. 7. Observations of Comets 1880, 1881, and 1882.
No. 8. Observations of Comets of 1883. (Entirely his own work)
No. 10. Micrometrical Measurements of Double Stars, 1882-86. (1091 Double Stars in list)

It might seem, in consideration of the amount of astronomical work done during these years at Cincinnati, that Dr. Wilson gave all of his attention to the heavens. This, however, was not the case, for on December 20, 1882, he was united in marriage with Miss Mary B.

Nichols of Cincinnati. They and their son and three daughters enjoyed a happy and ideal family life until Mrs. Wilson's death in 1924. The oldest of the children, Dr. Ralph E. Wilson, received inspiration for an astronomical career from his father, and he has filled important positions at the Lick Observatory, the Dudley Observatory, and is now a member of the staff of the Mt. Wilson Observatory. The three daughters are, Mrs. Ruth Wilson Geer, Los Angeles, California, Mrs. George W. Constans (Mary), Bismarck, North Dakota, and Mrs. W. H. Pye (Lois), Morristown, Minnesota.

Dr. Wilson spent the year after he left Cincinnati at the United States Naval Observatory, Washington, D. C., as computer for the Transit of Venus Commission.

In the fall of 1887, he returned to Carleton College as Associate Professor of Mathematics and Astronomy, and began an extended period of service to that institution in various capacities. It was here that he did his most significant work which was continued with unabated energy and enthusiasm until his retirement.

Dr. Wilson's distinguished contributions to the promotion of the welfare of the College may be mentioned under three distinct headings.

I. Teacher and Administrator

Throughout the entire period of thirty-nine years, from 1887 to 1926, teaching was a very large part, if not the major part, of his work. The teaching of mathematics and astronomy was united in a single department throughout this period, and members of this joint department took part in the teaching of both subjects. Dr. Wilson, because of his great interest in both, excelled in the teaching of both. The writer had personal evidence of this fact, for, coming to Carleton as a young instructor in 1909, he, during the first year, was a member of one of Dr. Wilson's classes in advanced mathematics, and later this impression was confirmed by many years of close observation. He possessed a fine appreciation of the niceties and refinements of this science, had a faculty for presenting difficult points in a clear manner, and enjoyed quite as much as did his students the thrill of comprehending the intricacies of mathematical analysis.

The teaching of astronomy was, if possible, even more satisfying to him. For many years the principal course in that department, in point of numbers, was the course in general descriptive astronomy. This, although not a required course, came to be considered as one of the very desirable courses in the junior year. There was always a treat in store near the end of the course. It was the imaginary trip to the moon upon which the class embarked with the teacher as the guide. Dr. Wilson, while always adhering to astronomical fact, gave freedom to his imagination as to mode of travel through space. The scenes met with upon arrival were depicted by means of lantern slides of authentic lunar photographs, and, without fully realizing what was happening, the students

received a vivid, accurate, and lasting impression of conditions upon the moon as they are revealed by the most careful study.

He was associated directly with the administration of the College as Dean of the Faculty from 1906 to 1910, as Chairman of the Department of Mathematics and Astronomy from 1908 to 1926, and as Chairman of a committee of three which was the head of the College in the year 1908-09, during which the College was without a president. Because of his long experience and acquaintance with the history and traditions of Carleton College, his counsel was always timely and very valuable in the deliberations of the faculty.

II. Director of Goodsell Observatory and Astronomical Research

Dr. Wilson became the director of Goodsell Observatory upon the retirement of Professor William Wallace Payne at the end of the calendar year of 1908, and continued in that office until 1926. His astronomical researches, however, begun at Cincinnati were continued at Goodsell without interruption from the time he returned to Carleton in 1887. One of the first projects Dr. Wilson carried out as director of Goodsell Observatory was the installation of a Riefler Clock in a constant-temperature room. This clock was an important addition to the time service which, having been inaugurated by his predecessor, was continued for a number of years under Dr. Wilson's direction. He also continued the program of weekly "open-nights" at the Observatory for the benefit of the public. This program required him or one of his helpers to be on duty every Saturday evening to manipulate the 16-inch refractor. As a matter of fact the evenings were very few when he himself was not present. In fact, whatever pertained to the observatory was his primary concern. He was exceedingly careful to see to it that the details were attended to promptly and thoroughly. Through his efforts a fine Gaertner measuring engine and other apparatus were added to the observatory equipment, as they were needed in the prosecution of the work.

Along with his duties as director, Dr. Wilson was always engaged in two or three lines of research. He enlisted the assistance of a number of persons and always generously shared with them the credit for results reached. A summary of the *Publications of Goodsell Observatory* indicates the various types of work in which he was progressively interested.

No. 1 (1890). Catalogue of 644 Comparison Stars, observed with the meridian circle during the years 1887-1889.

All the observations for this catalogue were made by Dr. Wilson, and he also made the reductions or closely superintended the necessary computations in making them.

No. 2 (1901). Longitude Determinations.

This publication consisted of three parts: I. Determination of the longitude of Carleton College Observatory from the United States

Naval Observatory, Washington, D. C. II. Determination of the difference of longitude between Iowa College Observatory at Grinnell, Iowa, and Carleton College Observatory at Northfield, Minnesota. III. Determination of the longitude of an astronomical station at South Heart, North Dakota. The chief part of all this work was done by Dr. Wilson. He was assisted by Professor Payne and Miss Charlotte R. Willard.

No. 3 (1901). Observations of Sunspots and Measures of Solar Photographs.

The results given in this publication were secured by Dr. Wilson, Miss Willard, and A. G. Sivaslian, an Armenian, student in astronomy.

No. 4 (1915). Observations of the Comets of 1913 and 1914.

These observations were made by Dr. Wilson; he and several others participated in the reductions.

No. 5 (1917). Photographic Observations of Asteroids.

In this publication Dr. Wilson adapted the method of reduction to suit the particular star catalogues used as reference. In the accumulating of the data, he was assisted by several persons. 155 asteroid positions are given.

No. 6 (1918). Photographic Observations of Asteroids.

Similar to No. 5. 49 additional asteroid positions are given.

No. 7 (1919). Measures of the Flash Spectrum.

These measures were determined from photographs made by Dr. Wilson of the total solar eclipse at Fraser, Colorado, June 8, 1918.

No. 8 (1920). Observations of Variable Stars of Long Period.

These observations were made with the 16-inch equatorial and 5-inch finder at Goodsell Observatory during the years 1916-19, by Dr. Wilson and others.

No. 9 (1920). Photographic Observations of Asteroids.

Similar to Nos. 5 and 6. 80 additional asteroid positions are given.

No. 10 (1924). Photographic Observations of Asteroids.

Similar to Nos. 5, 6, and 9. 106 additional asteroid positions are given, making the total number in Nos. 5, 6, 9, and 10 to be 390.

It will be seen from this summary that, in the production of each of these publications, Dr. Wilson was the moving spirit and the principal worker as well.

In addition to the local activities just enumerated, Dr. Wilson planned, and carried out as far as weather conditions permitted, four expeditions to observe total eclipses of the sun: to North Carolina in 1900, to Colorado in 1918, to California in 1923, and to Wisconsin in 1925. The first resulted in some photographs which were unusually good for that early period; the second furnished the plates upon which *Publication* No. 7, mentioned above, was based; the third and fourth were fruitless because of clouds.

He also engaged in several other important astronomical projects away from the College.

In the summer of 1904, he and Professor W. W. Payne took the 8-inch photographic refractor to Midvale, Montana, a place in the foothills of the Rocky Mountains, at an altitude of 4,790 feet above sea level. This was relatively early in the period of astronomical photography and the field for experimentation was large. The purpose of the expedition to Montana was "to determine whether or not there might be great advantage for photographic purposes, especially the photography of the faint nebulous regions of the sky in the high altitude which we could reach there over our moderate altitude on the Minnesota prairie." The weather conditions were very favorable and the undertaking resulted in securing a number of excellent photographs of nebulae and Milky Way areas in the Cygnus region. The conclusion regarding the advantages for celestial photography afforded by the higher altitudes was that the exposure time was, for the same results, about one-half as great in Montana as in Northfield.

The second such project was undertaken in the winter of 1910-11, which he spent at the Lick Observatory. The plan which permitted his absence from the College was that of the sabbatical furlough which was then being inaugurated. Just as the photographic experimentation in Montana was in the nature of pioneering in that field, so, during his stay at Lick, Dr. Wilson again expended his efforts in an unexplored region. This time it concerned the space motions of the stars. The material for such an investigation is furnished by parallax and proper motion determinations, which at this time were relatively few. Dr. Wilson, however, assembled the necessary information concerning one hundred stars and based his study upon those facts. As time permitted in succeeding years he continued his studies along these lines and brought to light evidence which seemed to indicate "star-streaming" as the idea was described at that time.

Other opportunities for concentrated research were afforded in 1916 through a half-year at the Harvard College Observatory, as exchange professor, and in 1920-21, a sabbatical furlough, which he spent at the Mount Wilson Observatory. At both places, among other work, Dr. Wilson gave considerable attention to the investigation of the possibility of obtaining radial velocities from plates taken through an objective prism, the purpose being to discover a method of obtaining radial velocities more quickly and in greater numbers.

The earlier references to the *Publications of Goodsell Observatory* indicate his extensive research in connection with variable stars, double stars, comet positions and comet orbits, and asteroids.

III. Editor of Astronomical Periodicals

The *Sidereal Messenger,* of which ten volumes were issued in the interval 1882-1891, was in the middle period of its existence when Dr.

Wilson returned to Carleton in 1887. Although his name does not appear on its editorial staff, he did contribute a number of papers to it, and, in all probability, he shared in the work attendant upon issuing this publication at the Goodsell Observatory. His name does appear as an associate editor of *Astronomy and Astrophysics* which supplanted *The Siderial Messenger,* and continued through the years 1892, 1893, 1894. This publication was edited jointly by Dr. W. W. Payne of the Goodsell Observatory and Dr. G. E. Hale, of the Kenwood Observatory, Chicago. This publication grew in size and increased in the amount of technical material included, and later became the *Astrophysical Journal.* POPULAR ASTRONOMY was begun in the fall of 1893 as more directly the successor to *The Sidereal Messenger* in that it emphaiszed the popular aspects of the rapidly growing science of astronomy. Dr. Wilson's name appears first as an editor in Volume IV (1896), along with the name of Dr. William W. Payne, the founder, and that joint relationship to POPULAR ASTRONOMY was maintained until 1909. In that year Dr. Payne retired from the College and Dr. Wilson assumed the entire responsibility. He continued as editor until 1926, when, in turn, he became Professor Emeritus.

In addition to the numerous notes and minor contributions which an editor naturally makes anonymously, the indexes of these several publications show that Dr. Wilson contributed numerous longer papers as well. Eleven such appeared in *The Sidereal Messenger,* eight in *Astronomy and Astrophysics,* and thirty-seven in the first sixteen volumes of POPULAR ASTRONOMY. In the succeeding volumes thirty additional papers by him are listed, the last one in 1938. A total of eighty-six papers, therefore, represents the more or less incidental work done by him in addition to his more extended studies the results of which were published elsewhere.

The routine matters, such as the selection of material, the correcting of proofs, the business correspondence, were carefully and punctually attended to by him. The printing was done in Northfield and it was a familiar sight for many years to see him walking between the Observatory and the printing office usually carrying a roll of proof.

One proposal made by Dr. Wilson, which has borne much fruit, might be mentioned. In the August-September issue for 1911, Dr. Wilson enumerated a short list of things which an amateur astronomer with meager equipment might undertake. One item in the list was the study of variable stars. He closed the brief note with the question, "Can we not have in America an association of observers with a 'Variable Star Section,' a 'Jupiter Section,' etc.? We invite correspondence in regard to the matter." In the next issue he was able to announce that Mr. William Tyler Olcott of Norwich, Connecticut, had become interested and had offered to take charge of the necessary correspondence in the direction of such a variable star section. A nucleus of observers for such an organ-

ization was already coöperating with Harvard College Observatory. In the following issue Mr. Olcott reports progress and lists the names of six persons who had signified their desire to coöperate, and concludes with the following paragraph:

"The writer takes the opportunity of thanking the Editor of POPULAR ASTRONOMY and Professor Pickering for the interest they have taken in this plan to organize an association of variable star observers, and if the monthly reports of this Association should prove of any interest to the readers of POPULAR ASTRONOMY, and of value to the Association, he will be amply repaid for his efforts to popularize variable star observing."

In the next issue, that for December, 1911, the first monthly report of the American Association of Variable Star Observers (A. A. V. S. O.) was made by Mr. Olcott as corresponding secretary. Fifteen observers were now at work. In this report 201 estimates of variables are given. By the time of the next monthly report, the number of observers had increased to twenty-five and the number of estimates in proportion. From this time on the growth was rapid. The monthly reports continued to appear in POPULAR ASTRONOMY until the end of 1935. By this time the estimates had increased to more than 54,000 a year, and a grand total of more than half a million had been published. Such extended activities of the Association exceeded the space and resources of the magazine, and since that time the observations are being published quarterly at Harvard College Observatory, and only Variable Star Notes, compiled by Mr. Leon Campbell, recorder, appear in POPULAR ASTRONOMY each month. Dr. Wilson was an honorary member of the A.A.V.S.O. from the beginning until the time of his death.

Dr. Wilson was a member of the American Astronomical Society and frequently attended its meetings. The 1925 September meeting of this Society was held at Carleton College upon his invitation. He attended also the Fourth Conference of the International Union for Cooperation in Solar Research at Pasadena and the Mount Wilson Observatory in September, 1910. This meeting with many astronomers from abroad made a deep and lasting impression upon him. In the light of the vicissitudes of this organization since that time, his report, published in the October (1910) issue of POPULAR ASTRONOMY, is very interesting reading today.

At the installation of the Carleton Chapter of Phi Beta Kappa in 1914, Dr. Wilson was elected to membership as an alumnus on the basis of his record as a student. At the installation of the Carleton Chapter of Sigma Xi in 1936, being then an emeritus member of the faculty, he was made an emeritus member of the Chapter in consideration of his active career in science.

Except for the few years which intervened between his graduation from Carleton College and his return to Carleton as a member of the

faculty, Dr. Wilson lived continuously in Northfield and its immediate neighborhood. He was ever known as an exemplary citizen. He took an active part in all constructive civic enterprises. He served for a number of years as a member of the Board of Education; he was for many years, except for the official title, the city surveyor, and was frequently called upon in his later years for information regarding points of reference with which he was thoroughly familiar; he was a member of the Congregational Church and served it in practically every capacity, notably as superintendent of the Sunday School for many years. He was naturally quiet and inclined to remain in the background, but his influence was always positive and persuasive.

At the time of his retirement from active service to the College, letters of appreciation and congratulations were published in this magazine from Walter S. Adams, Robert G. Aitken, Edwin B. Frost, Edward S. King, Frank Schlesinger, and Joel Stebbins, all of whom knew him intimately and had learned to appreciate his many commendable qualities. Introductory to these letters appeared the following paragraph which, I am sure, is the judgment of all who had the privilege of close association with him:

"The writer has had the opportunity of observing the work of Dr. Wilson for a long period of time. For seventeen years we have met almost daily in the office of Goodsell Observatory. During these years much of our work has been done jointly, Professor Wilson leading the way. Throughout this period, in editing the magazine as well as in all of his other work, he has always maintained a scholarly attitude toward study, an unswerving loyalty to duty, an unfaltering firmness in friendship, and a noble Christian spirit in all relationships."

Soon after his retirement he was married to Miss Florence E. Rice of Northfield. They were of mutual assistance, he to her in her business affairs and she to him in conserving his health which showed signs of weakening at that time. They spent the summers, as a rule, at a home on the shore of a lake in Northern Minnesota, and the winters frequently in California. Although he did not quite realize his expectations to continue astronomical research after retirement, he did retain a vital interest in that field. Once in his last illness when I called to see him, I found him deeply engrossed in a book describing the new observatory and equipment on Mt. Palomar. He suffered a severe illness in California in the winter of 1938-39 and was confined to a hospital there for a number of weeks. However, he recovered sufficient strength to return to Minnesota by automobile in the spring of 1939, but with the coming of winter again his strength began to ebb. He died March 9, 1940.

The funeral service was held in the Congregational Church in Northfield on March 11, 1940. Dr. Donald J. Cowling, the president of Carleton College, Dr. Robert Rasche, minister of the Congregational Church, and the writer, his associate for many years and his successor in a part

of his duties in the College, participated. Among the tributes paid to the memory of Dr. Wilson at that time, my feeling of admiration and esteem was expressed in these words:

". . . The items just mentioned are a few of the many which are on record and hence may be read by any one at any time. Other items which are not written down, indeed cannot be written down, are those subtler characteristics of his personality which are *sensed,* and *appreciated,* and *cherished* by those who have had the incalculable privilege of intimate acquaintance with him. Such persons quickly became aware of and shall not soon forget his genial and winning smile, his happy and friendly disposition, his even and unruffled temperament, his innate and ever-present gentlemanliness, his strong and resourceful intellect, his high and uncompromised ideals, his deeply-rooted and stalwart character, and his practical and genuine Christianity."

As one who has had that privilege, I feel that it is not extravagant to say of him, using thoughts of the ancient Thucycides, "He has the grandest of all sepulchres—not that in which his mortal remains are laid, but a home in the minds of men, where his glory remains fresh to stir to speech or action as the occasion comes by. For the whole earth is the sepulchre of famous men and their story is not graven only on stone over their native earth, but lives on far away, without visible symbol, woven into the stuff of other men's lives."

GOODSELL OBSERVATORY, CARLETON COLLEGE, APRIL 10, 1940.

Astronomical Exhibition at the Columbus Meeting of the A.A.A.S.

By ERNEST CHERRINGTON, Jr.

In view of the extensive character of the astronomical exhibits that formed a part of the annual scientific exhibition in connection with the Columbus meeting of the A.A.A.S., it has been suggested that a description of them be given here since it may prove useful to others contemplating similar displays. Dean Alpheus W. Smith of Ohio State University, Chairman of the Committee on Arrangements, asked the writer to assemble material for the customary booth on astronomy. At first it was planned that the displays should illustrate the history and progress of astronomy in Ohio. However, reflection and discussion emphasized the facts that the professional astronomers visiting the exhibit would be relatively few and that the primary purpose of the exhibit should be to convey to the general public and the non-astronomical members of the Association a representative picture of astronomical work in progress today. With this thought in mind, the directors of the leading observatories in the United States were approached with a request for models or

photographs that would illustrate some of the less abstruse programs of research. Our request was met by a spirit of hearty coöperation in almost every case. So generous was the response that the exhibit soon outgrew the original booth and expanded into three booths. The following institutions were represented:

Palomar Observatory. The celluloid model of the 200-inch telescope was on display. This was the original model of the great instrument made by the engineers at the Philadelphia Works of the Westinghouse Company for testing purposes. It was secured through the courtesy of

FIGURE 1

Dr. John A. Anderson, Executive Officer of the California Institute of Technology. Large photographic reproductions of two of Russell Porter's drawings of the telescope further illustrated details of the construction.

Mount Wilson Observatory. A large, photographic, mosaic map of the entire Milky Way, showing positions of Cepheid variable stars, was prepared from the Ross plates. Two photographs of N.G.C. 6553, one in blue and the other in red light, beautifully illustrated the effect of

selective absorption in the Sagittarius region. A series of carefully timed exposures of the Crab Nebula in violet, blue, yellow, orange, and red lights brought out some interesting structural features.

Lick Observatory. Three excellent photographs of the moon at different ages and three enlarged portions showing the regions of Copernicus, Tycho, and the Apennines were made from plates taken with the 36-inch refractor. The work of the Crossley reflector was represented by photographs of the Pleiades, M42, M31, and M8. An excellent copy of Dr. Wright's photographs of Mars and San Jose in violet and extreme-red rays was also included.

Observatories of the University of Michigan. An easel containing six transparencies illustrated various types of normal and peculiar stellar

FIGURE 2

spectra secured at Ann Arbor. A photograph of the 27-inch refractor of the Lamont-Hussey Observatory in South Africa, a photograph and Porter's drawing of the McMath-Hulbert Observatory, and a series of prominence photographs represented the other Michigan institutions. Two reels of solar motion pictures were shown and described at intervals in the exhibition hall.

Cook Observatory. The work of the astrographic cameras was splendidly illustrated by a large collection of beautifully mounted contact prints of plates taken with the 10-inch, 5-inch, and 3-inch Ross-Fecker lenses. A color print of the Observatory, numerous photographs

FIGURE 3

of the various instruments, and a collection of celestial objects completed the exhibit.

U. S. Naval Observatory. The photographic determination of time by means of star transits obtained with the zenith tube was illustrated by a series of seven transparencies. Three additional transparencies illustrated the study of sun-spot frequency.

Harvard College Observatory. A collection of thirteen prints of prominent and unusual objects photographed in the southern sky illustrated the work of the 60-inch reflector at Bloemfontein, South Africa.

Sproul Observatory. Investigations of double stars by means of photographic observations were illustrated by a series of eight photographs of close binaries made with and without the objective grating before the 24-inch refractor.

Dearborn Observatory. Various lines of research were represented by photographs of Eros, objective prism spectrograms, the light curve of the variable star R Cassiopeiae determined in four different wavelengths, and diagrams showing physical changes in Gamma Cassiopeiae.

Allegheny Observatory. Prints were displayed of typical parallax plates, magnitude plates of short-period Cepheid variable stars, asteroid position plates, and fringed solar spectrograms.

Yerkes and McDonald Observatories. A most ingenious model, constructed by Dr. G. P. Kuiper, showed the relations among the three fundamental variables in studies of stellar structure—mass, luminosity, and radius.

FIGURE 4

New York Museum of Science and Industry. Dr. S. B. Nicholson's model of the orbits of Jupiter's eleven satellites was exhibited in the "Astronomy in Ohio" booth because of its relation to the work of Dr. Paul Herget, of the Cincinnati Observatory, who computed the orbits of satellites X and XI.

Loomis Observatory. The small observatory on the campus of West-

ern Reserve Academy, Hudson, Ohio, was featured because of its historical interest. It has been in use for 102 years, and it is the oldest observatory west of the Allegheny Mountains. In fact, it was built only a few months after the observatory which claims distinction as the oldest in the United States. A portrait of its founder, Elias Loomis (1811-1884), was also on display.

Cincinnati Observatory. Photographs of the Observatory in its original and present states, some of its instruments, its first Director, Dr. O. M. Mitchel, and the charter of the venerable Cincinnati Astronomical Society were shown.

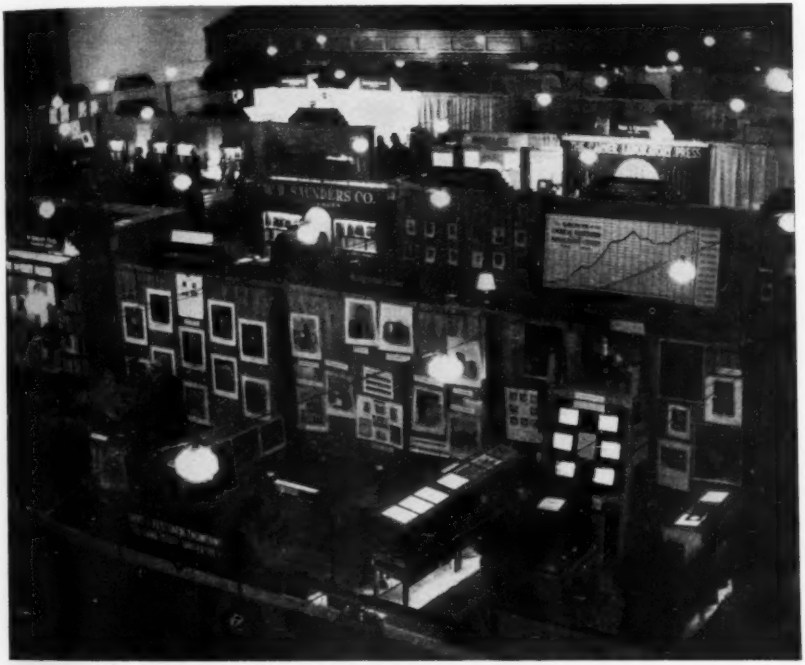


FIGURE 5

Perkins Observatory. Large photographs of the 69-inch reflector, the new two-prism spectrograph, and representative stellar spectra were on display.

Other Ohio astronomical institutions represented in pictorial form were the *Swasey Observatory* at Denison University, the *Warner and Swasey Observatory* at Case School of Applied Science, the *McMillin Observatory* on the Ohio State campus, and the *Ohio Wesleyan Students' Observatory.*

The exhibits were housed in the Civic Auditorium in Columbus, Convention Headquarters of the A.A.A.S., and were open from December 27 to 30, 1939. The writer wishes to express his sincere appreciation of the assistance accorded him by Professors Paul Herget, J. J. Nassau, and H. D. Curtis in planning and arranging the displays. He is also greatly indebted to the directors of the various observatories whose coöperation made possible the exhibition.

PERKINS OBSERVATORY, DELAWARE, OHIO.

The New Goethe Link Observatory

By VICTOR E. MAIER

The State of Indiana has needed more facilities for modern work in astronomy. In order to meet this need this institution was established in its entirety by Dr. Goethe Link, an Indianapolis surgeon. The observatory stands on a high bluff near Brooklyn, a small village about twenty-five miles southwest of Indianapolis.

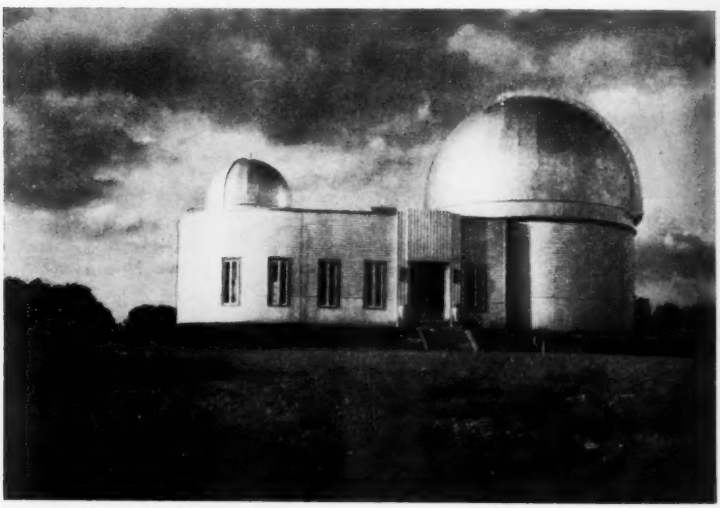


FIGURE 1

GOETHE LINK OBSERVATORY, BROOKLYN, INDIANA

The location is an admirable place for an observatory. From it the landscape is visible for many miles in all directions. It is approached by an auto road that includes a steep hill nearly a mile long. This is a rarity in Indiana which has mostly flat country. On clear nights the transparency of the atmosphere is excellent for astronomical work. The location

is far enough from Indianapolis to escape the lights and smoke, but close enough to make efficient city connections. Further, it is situated near the geographical median of a number of colleges and universities in the state.

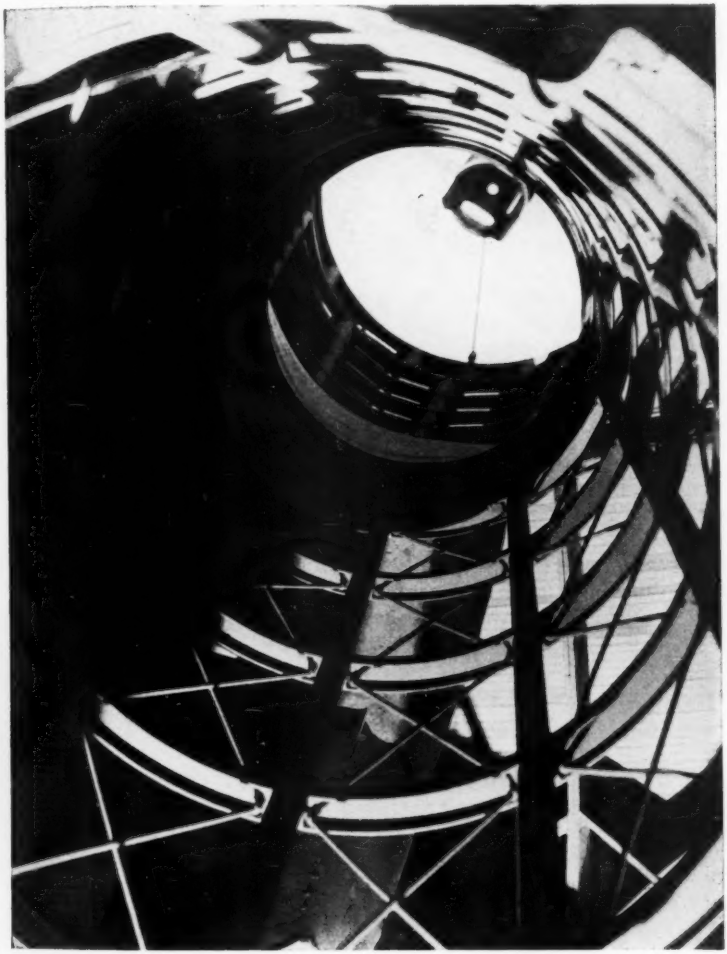


FIGURE 2

VIEW DOWN THE OPTICAL TUBE OF THE GOETHE LINK REFLECTOR. This shows the method of covering the mirror: with a stainless steel sheet that bends to the curve of the inside of the tube when open and flattens when it is closed. The photograph also shows the method of "tuning" the aluminum optical tube.

The observatory and its equipment were made by men in the Indianapolis area under the supervision of the writer. Work on the project was started when it was learned that the Corning Glass Works had a 36-inch mirror blank on hand, after they had shipped the 200-inch blank and its auxiliaries to California. The glass, similar in pattern and material to the 200-inch giant, was purchased through Mr. Carl Turner, an Indianapolis telescope builder. Everything else was designed to fit in with the 36-inch reflector, the principal instrument at the observatory. In both its design and construction its builders have tried to include the best features of other observatories along with many innovations.

The construction work arranged itself into four branches, all of which were started early in 1937. A grinding machine for large optical surfaces was designed and built by Mr. Turner. Mr. Charles Herman, a local mirror-maker, was given the task of finishing the parabolic surface. Mr. Turner and his associate, Mr. Klaisler, then turned their attention to the work of building the telescope mounting. Designs for the observatory building were done by Messrs. Tislow and Pittman, and the construction work by Mr. C. F. Bowers. Two and a half years were required to complete the work.

The telescope has a focal length of five times the diameter of the mirror. The mounting is the "German" counterbalanced type, selected as giving the greatest number of advantages. In appearance the telescope is similar to others of its size, but in its construction two basic departures from past practice were undertaken which have been found to be very satisfactory. Heretofore, nearly all telescope mountings have been made of cast iron parts, each part especially molded to fit its particular use. But in this instrument the new techniques developed in electric welding and oxy-acetylene cutting were used as much as possible. With this method, parts of any shape and description can be quickly made up from steel pieces purchased at any warehouse. Braces can be interposed where they are most needed. Great strength without great weight is therefore gained.

The other basic difference between this mounting and others is embodied in the concrete pier. The pier has the conventional curved yoke at its top in which the polar axis turns, but the bearing trunnions are bedded directly in the concrete. This has the effect of making the pier an integral part of the telescope mounting, and requires that the concrete be very accurately set on the earth's surface. Accordingly, excavation was made to bed rock, and the pier started there. The altitude of the pole and the direction of the meridian were accurately determined by observations made on stars with a transit instrument. Readings were made on the concrete every hour while it was hardening. It has since been found that the pier was set within one millimeter of the correct position even though it weighs 200 tons and its top extends thirty feet above the ground level. Its base measures 9x17 feet. It is hollow, and

provides an excellent fireproof "strong-box" on the first floor of the observatory.

After the pier was finished, the building was erected around it, care

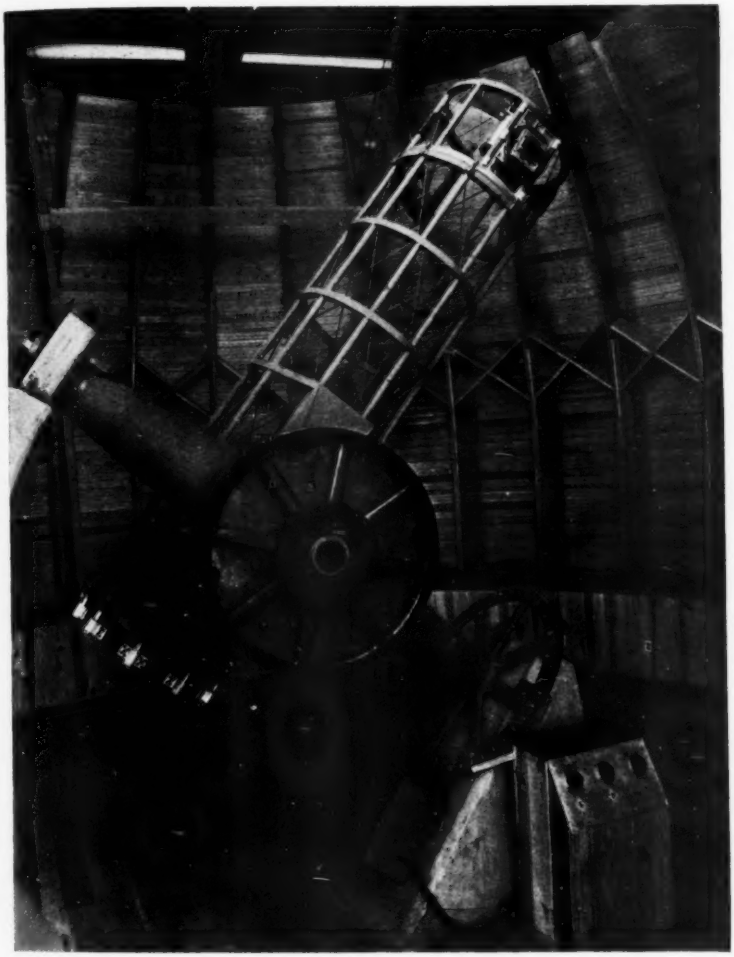


FIGURE 3

INSIDE THE LARGE DOME SHOWING THE REFLECTOR WITH NEWTONIAN FOCUSSING ARRANGEMENT AND DOUBLE-SLIDE PLATEHOLDER.

The electric driving unit is shown in its shatterproof glass case in mesh with the RA worm gear. Corners are blurred because of the extreme wide angle necessary to include the instrument. Floor controls are in right foreground.

being taken to keep them separated. The frame of the building is made of massive oak posts and beams that were cut from the forest a few miles from the observatory. The interior is finished with hardwood floors, panelled knotty-pine walls, and beamed panelled ceilings. It presents a pleasing, beautifully finished, rustic appearance. A hardwood spiral stairway leads to the upper floor and the large instrument. Another stairs opens on the roof, and allows access to the small dome.

Nearly half of the first floor is taken up by an auditorium with a seating capacity of 150 persons. The remainder contains a darkroom, astronomical laboratory and workshop, and living quarters for the staff. The building is not heated, but the living quarters and workrooms are kept comfortable in cold weather with electric unit heaters. These rooms are well insulated and the temperature in them can be raised from subzero to 75° Fahrenheit in a few minutes. Air currents that disturb the seeing are kept at a minimum with this method of heating. Electric power is purchased from the local utility, but the observatory has its own water system and fire protection. The large dome is always at the same temperature as the outside air.

The dome is 34 feet in diameter, and is provided with an opening eight feet wide, nearly three times as wide as the mirror. The length of the opening extends four feet past the zenith. Work near the zenith is convenient in any position of the dome. Two long shutters, weighing one ton each, cover the opening. They open and close at the push of a button. The dome is clad with steel terneplate and aluminum paint. Although its moving weight is 34 tons, the dome is rotated easily with a one-half horsepower electric motor activated by toggle reversing switches. The shutters and the dome are from Mr. R. W. Porter's design. He generously sent one of his famous "thumbnail" sketches from Mount Palomar.

The observing platform in the Goethe Link Observatory is a notable piece of equipment. Two long steel arches span the inside of the dome, and the floor of the platform is hung from them. The entire unit is independent of the dome, but rotates with it. The arches were made strong enough not only to hold the platform and its raising mechanism, but to contribute to the rigidity of the dome and the entire structure. The platform has a capacity of six persons and is run with electric power. Many of the ideas incorporated in this platform are those of Dr. Carpenter at Tucson, Arizona, who helped in its design.

The small, fourteen-foot dome houses a Zeiss apochromatic refractor. This instrument has a full complement of accessories, and is used for visual work. It affords beautiful views of all the familiar celestial objects. Its dome is a descendant of the well-known Burnham dome. It opens halfway, permitting the observer a view of half the sky at one time. Unlike the Burnham dome, this one is made entirely of steel, electrically welded into but two pieces. In order to reduce the heat of the

summer sun, the inside is treated with a special insulator that was sprayed on with a hose. The Zeiss refractor has an aperture of 130 millimeters, and is one of the very few fully corrected instruments in America.

While all these things were being assembled, the mirror and the mounting for the large reflector were being finished. Grinding and polishing were accomplished in the conventional manner in about ten months. The difficulties of figuring were eliminated one by one until the final, necessary perfection was reached. Many tests, both visual and photographic, were made to determine the accuracy of the finished surface. The Hartmann test yielded a "Hartmann criterion" of .066. (This figure is derived from Professor Hartmann's equation used in the test. It is essentially the diameter of the star image in seconds of arc, as produced by the mirror's surface.) The visual tests showed the surface to be even better. The result ranks the glass as one of the most accurately figured mirrors ever made. It was aluminized in Chicago by Mr. Clausing. The 12-inch Newtonian diagonal, recently completed, is flat to within one-tenth wave-length of red light.

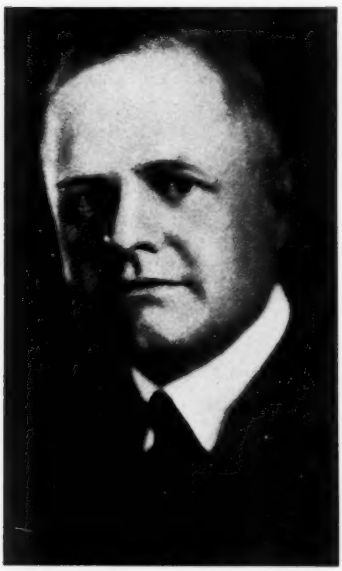
The large reflector mounting contains many new ideas, only a few of the most outstanding of which can be mentioned here. The welded steel axes are fitted with Timken precision bearings eight inches in diameter. Two large gears, that were made off the same pattern, control the motion in right ascension and declination. The right-ascension gear has a bronze ring shrunk on its perimeter into which 400 worm teeth are cut. The declination gear has a ring of internal teeth fastened to its side. The gear and setting circle are incorporated in the same piece. The saddle, to which the optical tube is fastened, is made up of a number of small steel pieces welded together. It is very strong and rigid.

In order to gain lightness and ease of control, the optical tube and all its accessories, are made of an aluminum alloy called Lynite. The tube itself contains over 500 pieces all of which are drawn together by an ingenious arrangement of tension struts. The arrangement allows the tube to undergo temperature changes without twisting, and reduces flexure to a negligible amount. The upper section of the tube rotates and allows the plateholder to be set in any desirable position. By using aluminum for the optical tube, welded steel for the rest of the mounting, and ribbed Pyrex for the mirror, over 5000 pounds have been spared from the moving weight of the assembly. As it is, its moving weight is 5200 pounds. The heaviest single piece is the 2000 pound counterweight, which is attached directly to the polar axis.

The telescope is controlled entirely by electric motors. Dual controls are mounted on the floor of the observatory and the observation platform. The high-speed motors which set the instrument have universal windings and are controlled by rheostats. This enables the operator to move the telescope quickly over large angles or to give it a very small

movement, slowly. The sidereal rate is accomplished through a synchronous motor and a special set of worm gears corrected for atmospheric refraction. There is also an electric differential for varying the rate. During the setting operation the telescope is automatically thrown out of engagement with the sidereal motor with an ingenious magnetic clutch. Although a double-slide plateholder has also been provided for guiding, the electric rate is so closely fixed that exposures of an hour or more have been made without touching the controls.

The observatory and its equipment have been inspected by many astronomers from all over the United States. All have been very kind in complimenting its excellence. Its builders are indebted to the many



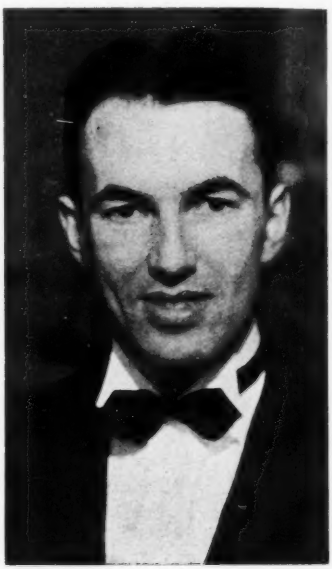


FIGURE 4

DR. GOETHE LINK, *Founder* VICTOR E. MAIER, *Director*

members of the profession for their generous help in making this institution practical, and placing it among the best. The most recent piece of equipment, a zero-coma-corrector using 4x5 plates is being finished in Indianapolis. It will be used in the prime focus, and was recommended by Dr. Harlow Shapley.

The institution was founded to aid in the advancement of astronomy in the state of Indiana. The equipment has been made available to the astronomy departments of the colleges and universities in the vicinity who can use it to advantage in their research problems. The program

of the observatory consists of the individual researches conducted by these universities. Dr. James Cuffey has already published his work on star clusters done with this instrument. Dr. Cuffey has the research fellowship from Indiana University and works full time at the observatory. Student lectures and visitors' nights are also a part of the program.

The administration of the observatory is vested in a non-profit corporation called " The Goethe and Helen Link Foundation for Scientific Research." The foundation has been endowed with a permanent income, and no charges are made for the use of the observatory's equipment. The directors of the corporation determine the policies of the observatory, and employ its workers. The writer has been installed in the capacity of director.

BROOKLYN, INDIANA, MARCH 1, 1940.

An Approach to the History of Astronomy

By EARLE G. LINSLEY

During the second semester of the academic year 1939-40 there was an opportunity at Mills College to organize and present a semester course of three hours in the History of Astronomy in what the instructor considers an original, interesting, and profitable way. There were twenty-five young women in the class, all of whom had had the elementary course; none of these expected to major in the science or to become astronomers, few had had any mathematics but all were interested in the development of astronomy. They also wished to have the history of the science presented in such form that at the end of the course they might feel acquainted with the astronomers and the observatories, together with the methods of work and the results achieved.

The choice of topics in the outline was limited somewhat by the materials easily available for reference. It was supplemented by an excellent set of lantern slides from the large collection at Chabot Observatory, including portraits of astronomers, pictures of observatories and equipment, and slides from the observatories themselves illustrating the work accomplished in their programs.

To each student was assigned one from each of the groups of topics (II, III, IV) which follow, and she prepared a paper and presented it before the class. When materials were available the paper was illustrated by lantern slides. The other members of the class were invited to ask questions on the topic, and were expected to take notes. The paper was then read privately by the instructor, factual errors were corrected, and it was then placed in typed form with some source materials, in a loose leaf binder for all members of the class to read.

The final examination consisted of general questions to be answered in brief essay form and one hundred true and false statements covering the

first three divisions of the course which follow. Each student had a mimeographed outline of the whole plan and a special outline and list of source materials for her special topics.

A skeleton of the outline is given here.

I. The Founders of Astronomy

The instructor laid a foundation by giving six introductory lectures covering most briefly the contributions of Thales, Anaximander, Philolaus, Plato, Eudoxus, Aristotle, Aristarchus, Eratosthenes, and Hipparchus. This gave the students time to find the materials and begin work making brief reports to be presented for discussion on the contributions of the astronomers listed below. Abundant reference material was available for this part. The students preferred Berry's "Short History of Astronomy," Ball's "Great Astronomers," and Macpherson's "Makers of Astronomy," as well as the few books which have been devoted especially to the lives and work of these astronomers.

The students were required to show the interrelations of the work of the men named in the following list in the special important contributions which they made in laying the foundations upon which the structure of modern astronomy has been built, with the dates of these contributions.

Pythagoras (569-470 B.C.)
Ptolemy (2nd Century A.D.)
Copernicus (1473-1543)
Tycho Brahe (1546-1601)
Kepler (1571-1630)
Galileo (1564-1642)
Newton (1642-1727)
Halley (1656-1742)
The Herschels,
  William (1738-1822)
  Caroline (1750-1848)
  John (1792-1871)
Rosse, Earl of
  (Wm. Parsons) (1800-1867)

II. Biographical Approach to Modern Astronomy

The following names were selected as representative of those who have made outstanding contributions to modern astronomy. The students were required to have a brief story of the lives of these astronomers and a careful and accurate statement of their contributions including knowledge of the equipment which was used and the observatories at which the work was done with the important dates. Each student had an assigned biography from this list.

Adams, W. S. (1876-)
Ball, Sir Robert (1840-1913)
Barnard, E. E. (1857-1923)
Brashear, J. A. (1840-1920)
Brown, E. W. (1866-1938)
Burnham, S. W. (1838-1921)
Campbell, W. W. (1862-1938)
Cannon, Miss A. J. (1863-)
Clark, A. G. (1832-1896)
de Sitter, W. (1872-1934)
Flammarion, C. (1842-1925)
Frost, E. B. (1866-1935)
Hale, G. E. (1868-1938)
Holden, E. M. (1846-1914)
Hubble, E. (1889-)
Keeler, J. E. (1857-1900)
Lockyer, J. N. (1836-1920)
Lowell, P. (1855-1916)
Newcomb, S. (1835-1909)
Pease, F. G. (1881-1938)
Pickering, E. C. (1846-1919)
Pickering, W. H. (1858-1938)
Proctor, R. A. (1837-1888)
St. John, C. E. (1857-1935)
Shapley, H. (1885-)
Swasey, A. (1846-1937)
The Struves,
  F. G. W. (1793-1864)
  H. (1854-1920)
  O. (1897-)
Wright, W. H. (1871-)
Young, C. A. (1834-1908)

All of these names appear in the Index of Names in the texts used in the course, which were Baker's "Astronomy" and Waterfield's "One Hundred Years of Astronomy." The selections for biographical sketches were limited to easily available materials. Few living astronomers are included because brief biographies of living astronomers with a summary of their work are not regularly available unless such work has been summarized at the time of the presentation of some award. The selections were also made to include a few foreign astronomers and observatories for which material was at hand. Other astronomers and observatories were included in brief discussions by the instructor, but the subjects presented by the students are the only ones listed here.

Brashear, Clark, and Swasey were included to bring into the picture the problems involved in making the astronomer's tools. All members of the class were encouraged to read selected sections in Brashear's "Autobiography," Frost's "An Astronomer's Life," Newcomb's "Reminiscences of an Astronomer," and Woodbury's "The Glass Giant of Palomar."

Of course probably no other instructor would make the same selection for biographies. It is important that the materials be at hand in easily accessible and usable form for those selected. Much of this material is found in biographical sketches in the astronomical periodicals and reprints in Chabot Observatory Library.

III. Approach to Modern Astronomy through the Programs of Observatories

The purpose was to have a general knowledge of the observatories here listed, including an understanding of the purpose of the founding, the programs at present, the special contributions which have been made, and the instruments with which these investigations were carried on, together with the astronomers who made them.

Allegheny	Griffith	Mount Wilson	Smithsonian Astrophysical
Chabot	Harvard	Oxford	U. S. Naval
Cook	Lick	Palomar	Yerkes
Dominion Astrophysical	Lowell	Paris	South African Observatories
Dunlop	McDonald	Peking (Ancient)	Zeiss Planetaria
Greenwich	McMath	Perkins	
	Meudon	Radcliffe	

Chabot Observatory was selected because it is the one in which the Mills College students do their astronomical observing and much of their study, and because it is organized to further public education in astronomy and carries on a full program of public service. Griffith Observatory was also included because of the educational program, and Peking Observatory because of the old instruments here. Again selection was limited in part by available material.

IV. Special Topics in Modern Astronomical Investigations

About one half the time was given to these individual reports. Of course there was some overlapping and interrelation between approaches II, III, and IV, but this was expected and desired to unify the course. The material was derived from Baker's "Astronomy" (class text), Waterfield's "One Hundred Years of Astronomy," and original papers on each subject from bulletins and reprints in Chabot Observatory Library. The presentation was historical. The student was expected to show the history of the investigation or contribution and present status. The following list of topics is somewhat abbreviated from that used in the original outline.

The topics were these: spectroscopy, photography, solar study, sunspots, evolution of stars, novae, binary stars, variable stars, white dwarfs, red giants, source of energy in stars, atoms and spectra, galactic nebulae, spiral nebulae, globular clusters, rotation of galaxy, absorption in space, meteor study, search for planets, planetary atmospheres, measurement of stellar distances, and, as especially suitable for our class, astronomy as a profession for women, and the amateur's contribution to astronomy.

If the divisions of this outline have been followed so far the reader will quickly see that the presentation of these topics reviewed the preceding topics. The students, however, felt far better acquainted with, for instance, Hubble, Mount Wilson Observatory, and the program there, when the subject of spiral nebulae was thus approached than others had in past years when the more conventional approach was used.

Chabot Observatory and Mills College, April, 1940.

Martian Features in 1939

By ROBERT BARKER

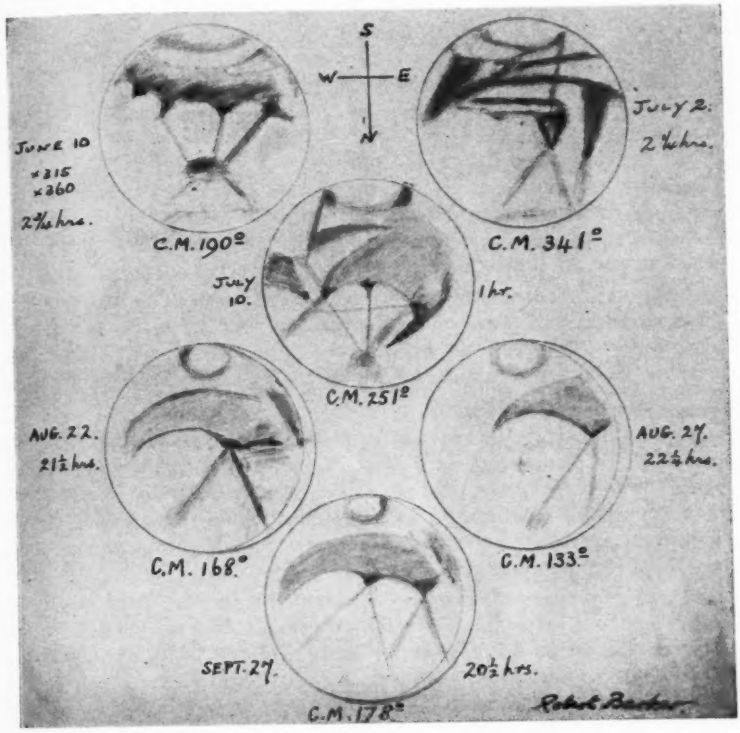
[Fellow of the Royal Astronomical Society]

The apparition of Mars (at opposition on July 23, 1939) was not anticipated by observers in Great Britain with much hope; for the Declination was extremely low, averaging S. 25°, around the period of the planet's best presentation. An insurmountable barrier appeared to be raised against steady definition, and the recording of interesting, intricate detail generally associated with Mars.

Theory postulated that Mars, at so low an altitude, would present a disc of ill-defined, bleary detail; but, although this condition certainly prevailed on some nights, on others practice strangely routed theory (a frequent happening in telescopic matters) and excellent, steady seeing was happily obtained.

Unsettled skies and much inclemency of weather were however experienced during the best observational period.

Six observations, extending over a period of 3½ months, are described in order to date. The drawings are copied exactly from the original records in notebook, and any small positional errors have not been corrected. It is a rule of the writer never to alter any Martian feature, away from the eyepiece.



MARTIAN FEATURES IN 1939

C. M. 190° (June 10, 2¾ hrs.). Here the great oasis and canal junction, Trivium Charontis, is on meridian,—a large dark area, S. of an intensely white district stretching N. to polar regions. The canals Tartarus, Laestrygon, and Cerberus (from left to right) were very distinct (especially the Cerberus) extending from very dark carets on the N. shore of Mare Cimmerium to their junction at Trivium Charontis. Mare Cimmerium, in aspect true to its name, was extremely dark (blackish blue-grey) broken on the extreme E. by the light streak Hesperia. The Styx was glimpsed leaving the S.E. border of Trivium Charontis, to Hecates Lacus. The South Polar Cap was large, irregular, with a distinct, wide, grey border.

C. M. 341° (July 2, 2¼ hrs.). This region seems to afford the finest and most interesting Martian scenery. The early morning was hazy, and a fainter Mars had the compensation of steady seeing. Canals Hiddekel, Gihon, and Oxus reached N. across a bright, faintly orange-hued desert, but the Phison and Euphrates were not seen running from their carets on Portus Sigeus. Extreme W., Syrtis Major loomed darkly, and Sinus Sabæus appeared a narrow blue-green strip with its S. and N. "coasts" sharply divided by a very white separation. This white, latitudinal streak seems to have increased during recent oppositions, the N. outline of Sabæus appears very indistinct, and canaliform in outline. Fastigium Aryn (Forked Bay) was insistent, but the forked separation could not be determined. Margaritifer showed clearly extreme E. Deucalionis Regio was easy, with the narrow streak of Pandore Fretum definitely dividing Deucalionis from Pyrrhoe Regio. This latter, and Noachis R., farther S., were very bright orange, and Hellas on the W. was also warmly tinted, instead of its usual snowy whiteness.

A very distinct canal running from the S. to Forked Bay was seen, the observer having no previous knowledge of this lineal marking. It was afterwards discovered to be Lowell's canal, the Neudrus. Canals S. of Sabæus are seldom seen here, and this is the first time Neudrus has been seen in the British Isles.

C. M. 251° (July 10, 1 hr.). A fine region of much detail, well displayed in the planet's present tilt, and some previously unrecorded features were noted. Nubis Lacus on the meridian, extreme N., receives the Amenthes, a canal central on disc (name unknown), and the Thoth. The great canal Nepenthes was seen crossing these three canals, ending W. at the clearly marked Cerberus.

Mare Cimmerium was extreme W., divided from M. Chronium (higher S.) and M. Tyrrhenum by the light division Hesperia. Thyle II Regio appeared N. of the South Polar Cap, and the canal Xanthus showed running from Polar Cap to Hesperia. Syrtis Major curved in from the E. limb. The carets on M. Tyrrhenum were strongly marked. A fine comprehensive view of typical Martian scenery, obtained in rather favorable conditions.

C. M. 168° (August 22, 21½ hrs.). Mare Svienum appeared as a chequered, blue-green region, with the light division Atlantis towards E. terminator. The Brontes was coarse and dark as it was N.W. from the prominent caret Titanum Sinus (where it met the Titan) to an ill-defined, darkish oasis near W. limb.

C. M. 133° (August 27, 22¼ hrs.). Here Lowell's "Beak of the Sirens" is well displayed, terminating sharply in the Araxes. This Mare was a light, transparent, blue-green, with the dark caret of Titanum Sinus marking the departure of Brontes and Titan.

C. M. 178° (September 27, 20½ hrs.). This agrees in most details

with the observation of August 22 (the meridian having advanced only 10°) except that a canal was seen traversing the Memnonia Region, N. of Mare Sirenum, towards W. limb (the Medusa) and an unknown canal leaving the same caret, which appeared to join Brontes on meridian. This is the last observation giving definite Martian features.

Telescope—12.6-inch Calver, clock-driven, equatorial, 120 inches focal length. Eyepieces—Browning achromatic ×315, Tolles' (by Dall) ×360. Positions of features in good agreement with Harold Thomson's charts.

CHESHUNT, HERTS, ENGLAND, FEBRUARY 5, 1940.

Planet Notes for June, 1940

By R. S. ZUG

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time, 6 hours, etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac*.

Sun. The sun is moving in an easterly direction during June, through the constellations Taurus and Gemini, entering the latter on June 20. Summer begins June 21, $13^h\,37^m$, the instant at which the sun is centered on the summer solstice.

Moon. Phenomena of the moon will occur as follows:

		h	m
New Moon	June 6	1	5
First Quarter	13	1	59
Full Moon	19	23	2
Last Quarter	27	18	13
Perigee	June 14	15	
Apogee	27	11	

Mercury. Mercury will be in the evening sky during the month of June, and will reach a greatest elongation from the sun of 25° 18′ on June 24. At this time the planet's declination will be +21°, so that it should be visible for an hour or so after sunset.

Venus. Venus will rapidly fade from view as an evening star during June. Although 2½ hours from the sun on June 1, its elongation decreases so that the planet reaches inferior conjunction with the sun on June 26, 21^h. At inferior conjunction the planet will be 58″ in angular diameter, and 26,921,000 miles from the earth. A small portion of its visible disk, 0.003%, will still be illuminated by the sun's rays, due to phase, and the magnitude of the planet will be —2.9. Venus will be in conjunction with Mars, and 22′ to the north of it, on June 7, 6^h.

Mars. Mars is gradually drawing nearer to the sun in angular elongation. By the end of June the planet will be but an hour and a half east of the sun, and quite inconspicuous in the evening sky. A conjunction with Venus on June 7 is noted above. A conjunction with Mercury will occur on June 17, 1^h, at which time Mars will be situated 26′ to the south of Mercury.

Jupiter. Jupiter is now a morning star of stellar magnitude —1.7, situated in

the constellation Aries. By June 30, it will rise some 3 hours before the sun. Two occultations of Jupiter will occur during the month, on June 2, and on June 30, both invisible in the United States.

Saturn. Saturn is a morning star, situated a few degrees to the east of Jupiter in the constellation Aries, and is of stellar magnitude +0.6. Saturn will be occulted by the moon on June 3, and again on June 30, neither event being visible in the United States.

Uranus. Uranus is now a morning object, situated in the constellation Taurus. Apparent positions of the planet for June 1 and June 30, respectively, are:

$\alpha = 3^h\ 23^m1,\ \delta = +18°\ 17'2;\ \alpha = 3^h\ 29^m2,\ \delta = +18°\ 39'5.$

Neptune. Neptune is an evening object, situated not far from the 5.8 magnitude star, 89 Leonis, as illustrated by the chart on page 31 of POPULAR ASTRONOMY for January, 1940. The apparent motion of the planet changes from retrograde to direct on June 4.

Occultation Predictions

(Taken from the *American Ephemeris*)

Date 1940	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′										
June 10	A^1 Cnc	5.7	1 6.6	—0.7	—0.6	63	1 47.6	+0.3	—2.5	333
16	λ Vir	4.6	5 11.7	—1.1	—3.3	164	5 43.7	—0.5	+0.3	222
18	73 B.Sco	6.4	1 51.3	—1.4	—0.5	132	3 0.3	—2.1	+0.5	253
18	88 B.Sco	6.4	4 41.0	—1.7	—1.5	130	5 44.2	—1.4	—0.3	241
25	186 B.Aqr	6.2	5 12.4	—0.9	+2.2	56	6 27.2	—1.4	+1.3	263
OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′										
June 10	A^2 Cnc	5.7	2 57.0	+0.1	—2.1	142	3 42.9	0.0	—0.9	254
16	λ Vir	4.6	5 0.5	..	..	179	5 22.9	..	..	214
18	73 B.Sco	6.4	1 40.3	..	..	168	2 13.2	..	..	222
18	88 B.Sco	6.4	4 12.3	—1.6	—1.4	143	5 12.1	—2.2	+0.7	237
25	186 B.Aqr	6.2	4 56.3	—0.3	+2.0	61	6 1.9	—0.7	+1.4	265
OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′										
June 1	88 Psc	6.2	11 31.8	—0.6	+0.9	105	12 24.4	—0.3	+2.7	209
14	162 B.Vir	6.0	3 39.0	—2.3	—0.1	85	4 47.5	—1.2	—2.3	327
14	200 B.Vir	6.3	6 5.8	—1.3	—0.8	84	7 7.4	—0.7	—2.2	318
18	χ Oph	4.8	10 24.6	—0.7	—0.4	66	11 24.7	—0.8	—1.8	294
21	ρ Sgr	4.0	11 54.6	—2.2	—2.2	121	12 45.5	—0.2	+1.3	207
29	ο Psc	4.5	11 25.1	—1.3	+1.2	94	12 32.1	—0.9	+2.6	217
30	Saturn	0.6	19 43.2	—1.3	+1.5	34	20 34.8	—0.6	—3.1	304

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

Due to a variety of circumstances almost nothing has been reported to the A.M.S. during the past month, and the need for getting out one of our regular Publications has taken up all my time, so that I have been unable to work up observations still awaiting reduction. However, after June this situation should end, and I hope to have more regular Notes from then on.

The one very interesting thing which has come to my notice is the following report, kindly sent us from the Hydrographic Office, U. S. Navy. It will be quoted as written . . . "On January 24th, at 14:30 G.M.T. while in Lat. 15° 05′ N. and Long. 93° 00′W., Mr. W. T. Blakiston, Jr., 3rd Officer was taking a bearing of Mt. Tacoma, a volcano. Suddenly a very large meteor was observed traveling in a Southerly direction, quite low over the mountain range, and bearing in an E.N.E. direction from ship. As he watched it, it suddenly passed behind a small peak, and apparently hit at the foot of Mt. Tacoma, on the North side of the mountain.

"Immediately after it landed, a cloud of smoke appeared, and a bearing of the smoke taken then was 82° true, from ship. Checking on position the spot where the meteor landed would be in 15° 12′ N., and the longitude would be approximately 92° 11′ W. The time at ship was about 8:12 in the morning and the visibility was very good. We were in close along the shore, as there was a strong Norther blowing in the Gulf of Tehuantepec. Yet in spite of the brightness of the day, the meteor was very bright, yellowish green in color, and had a long tail. It was at least five times as large as Venus.

"This is something out of the ordinary, and I think it should be investigated. . . . I do not think it would be very hard to locate. It lies just north of, and close to the border between Mexico and Guatemala. (Signed) Edwin E. Johnson, Master." His ship was *M.S.S. Oregonian* of the American-Hawaiian Steamship Company.

Shortly after this report came into my hands, I wrote to Dr. Gallo, the director of the National Observatory of Mexico at Tacubaya. In my letter I suggested that it would be in the interest of science to have the Mexican authorities in the vicinity undertake a search of the area in question. Of course I know well how deceptive the phenomena of fireballs are: people often think them near when actually they are scores of miles away. I had a very prompt reply from Dr. Gallo saying he had gotten in touch with the authorities in the region, but telling me that the area was little known and hence anything would probably be very difficult to locate. In any case there is a chance that something of interest will be found.

One of the immediate effects of the war is that reports on bright meteors from ships have become less frequent. Watch officers naturally have such heavy responsibility for their ships' safety that they feel little inclined, I fear, to make scientific observations. Also foreign ships do not like to publish reports giving their positions on past dates as this information might be of future use to enemy U-boats or raiders. So we may expect a further decline of reports as the war becomes wider. I vividly remember the effects of the World War upon the regular A.M.S. reports. They dropped from some 10,000 meteors in 1916 to about 600 in 1920;

people just were putting their attention upon other things. It is certainly to be hoped that, no matter what is ahead of our own country as well as the rest of the world, at least some of our members will not let up in their activity.

Reprint No. 4 was mailed to all our active members some weeks ago. If there is anyone who has not received his copy, he should let us know, giving a corrected address. Members still delinquent in their dues are asked to please send them in, and thus save the trouble and expense of a second bill. Also, members who expect to be active in summer are asked to write some weeks in advance for such maps and blanks as they expect to need, so that they can be sent well ahead of time. Waiting until the last moment often means that they do not arrive when needed, as we cannot always give instant attention to late orders.

1940 April 15, Flower Observatory, Upper Darby, Pennsylvania.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD,
Department of Astronomy, University of California, Los Angeles

President of the Society: H. H. NININGER, Colorado Museum of Natural History and American Meteorite Laboratory, Denver
Secretary of the Society: ROBERT W. WEBB, Department of Geology, University of California, Los Angeles

The Determination of Meteoritic Densities[1]

By JOSEPH F. FOSTER, JR.,
Department of Mathematics and Astronomy,
State University of Iowa, Iowa City

ABSTRACT

The densities of specimens of the meteorites Holbrook, Arizona, Llano del Inca, Atacama, Chile, Xiquipilco (Toluca), Mexico, and Admire, Kansas, have been determined (*v.* Table 1, *post,* for results). The influence of the immersion-liquid on the value of the density obtained is discussed, and examples are given. This influence is small but definite; it is especially important if the meteorite is in the form of filings or powder. The maximum error for some of the densities determined for this report is calculated and discussed. It was found to be small, particularly when the meteoritic specimen was large and the immersion-fluid was relatively dense. Lastly, rational methods of determining densities of meteorites are discussed and suggestions are offered for a method of calculating the densities of meteorites that are not suitable for immersion in liquids.

The investigation reported on in the present paper had as its goals: (1) the accurate determination of the densities of certain meteorites for which density-determinations have not, apparently, previously been made; (2) the study of the effect of the liquid in which the meteorites are immersed upon the resulting density-determinations; (3) the determination of the effect of slight inaccuracies in measured masses or tabulated densities on calculated densities of the meteorites; and (4) the presentation of a rational method for the determination of the densities of meteorites.

A calculation using the formulas for meteoritic accretion to the earth's mass, as developed by La Paz,[2] shows that an error of 0.01 in the determination of the average density of iron meteorites will result in an error of the order of 10^6 grams per year in the calculated total meteoritic accretion! Despite the fact that accurate density-determinations of meteorites are therefore very important, available information on such determinations seems to be very slight. The records of 247 meteorites listed in Farrington's *Catalogue of the Meteorites of North America to January 1, 1909, Mem. Nat. Acad. Sci.*, **13**, 1915, were examined for any possible information about the specific gravity of the meteorites. This examination showed that only 155 of the meteorites have had density-determinations reported for them and that, even for these, little information, except the reported value, is given. The nature of the immersion-fluid is stated for only 6 of the meteorites listed, namely, Adargas, Chihuahua, Mexico; Algoma, Wisconsin; Botetourt County, Virginia; Coon Butte, Arizona; Farmington, Kansas; and Modoc, Kansas. In all of these cases, water was used as the immersion-fluid, although, in the case of Botetourt County, another determination was made with the use of alcohol. The size and condition of the specimens tested are stated only rarely. Although other catalogs, also, were consulted, no reports of specific gravity determinations were found in them.

In connection with the first problem stated earlier, density-determinations accurate to 0.003 were made for the previously unmeasured meteorites, Llano del Inca, Atacama, Chile, and Holbrook, Arizona, (10 specimens), and for the previously measured meteorites, Xiquipilco (Toluca), Mexico, and Admire, Kansas, with alcohol as the immersion-fluid. The results of these determinations are given in Table 1 of this report.

TABLE 1

Name of Meteorite	Weight (grams)	Condition	Density
Holbrook (1 large)	9.9382	Crusted	3.517
Holbrook (9 small)	5.6094*	Partially Crusted	3.460
Llano del Inca	11.9900	Crusted	3.212
Xiquipilco (Toluca)	31.1129		6.932
Admire	8.6229	Badly Cracked	3.747

*Total weight of 9 specimens.

In experiments on the density of fine powders, it has been demonstrated that notable changes of density, dependent on the nature of the immersion-fluid used, occur. Culbertson and Dunbar[3] report the following density-determinations for charcoal and silica powders at 25° C., with various liquids (see Table 2). In view of the surprisingly large difference in specific gravity found in these experiments,

TABLE 2

Liquid Used	Density — Charcoal	Density — Silica
Water	1.821	2.246
Benzene	1.994	2.149
Carbon tetrachloride	1.860	2.132
Petroleum ether	2.083	2.125

it appeared desirable to determine the effect of change in the immersion-fluid on the density-determination of meteorites. In this connection, density-determinations were made for the meteorites Xiquipilco (Toluca), Llano del Inca, and Holbrook, immersed in carbon tetrachloride, in addition to those in which alcohol was used.

These results (Table 3) show that the density determined for a meteorite is noticeably, although not greatly—unless the meteorite is in comminuted form—affected by the liquid in which it is immersed. However, the effect is great enough

TABLE 3

	Density	
Name of Meteorite	Alcohol	Carbon Tetrachloride
Holbrook (large sample)	3.517	3.504
Holbrook (small sample)	3.485	3.477
Llano del Inca	3.212	3.198
Xiquipilco (Toluca)	6.932	6.921

so that all reports on meteoritic density-determinations should include a precise statement as to the nature of the fluid in which the meteorite was immersed in the process of the determination of its specific gravity. Since, according to the experiments of Culbertson and Dunbar,[3] this difference of density for various immersion-fluids is due primarily to the forces of attraction at the solid-liquid interface and to the compressibility of the liquid used, the greater density-difference found by them can be explained by reference to the much larger surface-area exposed to the liquid in their experiments. However, the differences found for the meteorites are of sufficient importance to make it seem advisable that, as just stated, all reports of the specific gravity of meteorites should include a definite statement concerning the immersion-fluid used in the determination. This point is of special importance when the specimen tested consists of comminuted meteoritic material.

In connection with the third problem mentioned previously, use was made of the differential calculus to determine the approximate error introduced into the meteoritic density-determinations by errors of specified magnitude in measured or tabulated quantities. In order to find this, we need to compute only the differential dS of S by use of the formula

$$dS = \frac{M}{L}\,dD + \frac{D}{L}\,dM - \frac{MD}{L^2}\,dL,$$

which is obtained from the formula

$$S = \frac{MD}{L}$$

for the specific gravity of the meteorite, where M is the weight of the meteorite in air, D is the specific gravity of the immersion-fluid, and L is the loss of weight of the meteorite when it is immersed in the liquid. The results of some sample calculations are given in Table 4, where an error of 0.1% for each individual term of

TABLE 4

M	D	dS
31.1161	0.78992	0.011
0.6598	0.79223	0.039
0.6591	1.5977	0.009
9.9378	1.5967	0.003

the equation is assumed. This calculated error varies greatly for the different specimens and liquids used. The greatest error possible, about 0.04, is found in the case of a small specimen and an immersion-liquid of low density. The maximum error is much smaller for the larger samples and for liquids of greater density. However, the errors made in the density-determinations reported on in this

paper are believed to be much less than the maximum calculated error.

In determining meteoritic densities, the ordinary suspension method can be used in most cases, if care is taken in selecting an immersion-liquid which will not react with the meteorite to be tested. When this method is used, the size and condition of the sample tested and the kind of liquid, as well as its density, used for the immersion, should be stated. When the meteorite is in powder form, a pyknometer may be used in the determination of the density; in this case, it is even more important that the type of immersion-fluid used should be stated. There are a few meteorites, such as, *e.g.*, Pasamonte, New Mexico, which cannot be put into a liquid because they are too easily soluble. Bannister and Hey[4] have developed a new micro-pyknometric method, which requires a sample of only a few milligrams to obtain an accurate value for the density. Unless the owner of the meteorite is willing to lose a small sample, a method of density-determination using air, or some other gas, must be developed. If this method is used, it is necessary to place the meteorite in a container of known volume and then to exhaust the air from the container. The amount of air removed must be measured rather accurately; the use of a relatively small container will increase the accuracy. Paneth and Urry[5] have successfully developed a method for measuring the amount of helium in a meteorite, and it seems likely that a modification of their apparatus could be applied to the determination of the amount of air removed from the container. In any case, a definite statement should be made regarding the accuracy of the determinations, the size and condition of the meteoritic specimen investigated, and the medium used in the determination.

NOTE AND REFERENCES

[1] Condensed from a thesis submitted in partial fulfilment of the requirements for the B.A. Degree, with Honors in Mathematics and Physics, at the Ohio State University. Presented at the Seventh Annual Meeting of the Society, Columbus, Ohio, December, 1939. The writer was introduced by Dr. Lincoln La Paz, Department of Mathematics, Ohio State University, Columbus.

[2] *Astr. Nach.*, **267**, 107, Nov., 1938.

[3] *Jour. Am. Chem. Soc.*, **59**, 306, Feb., 1937.

[4] *Min. Mag.*, **25**, 30, Mar., 1938.

[5] *Zeits. f. Phys. Chem.*, **152*A***, 110, Jan., 1931.

Representative Appointed to the Pan-American Science Congress

Vice-President W. F. Foshag (United States National Museum, Washington, D. C.) has been appointed by the Executive Committee of the Council to serve as the official representative of the Society at the Pan-American Science Congress to be held in Washington, D. C., from May 10 to May 19, 1940.

March 27, 1940. ROBERT W. WEBB, *Secretary*

Greenville (Illinois) Stone Examined

Several years ago it was suggested that, as the opportunity afforded, an examination should be made by those competent to do so, of all such stones as have from time to time been seriously claimed to be of meteoric origin, and that reports be published upon them, with two objects in view. First, there is always the remote possibility that some of these may prove to be genuine, and may thereby be preserved for scientific purposes; and second, such reports may make it unnecessary for others to travel great distances, only to learn that they have gone on a "wild goose chase."

In February, 1936, there was published on page 28, of the *P. E. O. (Sisterhood) Record,* the following item of news:

> *A Unique Monument:* Every year another monument is placed somewhere to memorialize Abraham Lincoln. A recent one, placed at Greenville, Illinois, is a meteor weighing 3,000 pounds that fell on a farm a few miles from the town.
>
> This is perhaps the most durable of any monument, since meteors are so hard that they are impervious to the ravages of time. The stone masons spent a full week drilling the four holes necessary to attach the tablet, placed by the Benjamin Mills Chapter, D.A.R., which was responsible for the monument which marks the spot of one of the Lincoln-Douglas debates, held September 13, 1858. In varying atmospheric conditions the meteor changes its color, one day green, another blue, yellow, or bronze.

Quite naturally my curiosity was aroused upon reading anything stated so positively as the above, and, on being in the vicinity of Greenville, I took advantage of the occasion to go and "have a look." No trouble was experienced in finding the monument mentioned, and I was also not greatly surprised in finding it to be only a large glacial boulder of compact igneous rock, of a type, more or less abstractly mentioned in the literature as "greenstone." During some earlier period of its existence it had evidently been badly fractured, for through it were innumerable fine cracks running in almost every direction, which had been shot through and completely sealed with pure white quartz. There was absolutely nothing about it to suggest any other origin, especially meteoritic, and an "old timer" in the vicinity told me it had been removed from a gully on the farm of Russell Chapman, some three or four miles north of town. The writer has seen literally hundreds of pieces of identical and similar material in the glacial drift, scattered all over the central west, and so there can be no doubt in his mind as to its terrestrial origin.

BEN HUR WILSON.

Joliet Junior College, Joliet, Illinois, April 1, 1940.

Comet Notes

By G. VAN BIESBROECK

COMET 1940 *a* (KULIN). According to a letter addressed by G. Kulin of the Budapest Observatory (Hungary) to the Central Bureau of Astronomical Information in Copenhagen, the asteroid 1940 AB showed less sharp on photographic plates than the surrounding stars. It was found by him on January 6 and also recorded as a trail of a 15.8 magnitude object on January 11, 12, and 30. From these data G. Kulin computed the following orbit:

Perihelion	= 1939 Oct. 3.52122 U.T.	
Node to perihelion	= 292°.754645	1950.0
Longitude of node	= 137.633625	
Inclination	= 4.802019	
Eccentricity	= 0.4476941	
Perihelion distance	= 1.749439	
Period	= 5.6374 years.	

The high value of the eccentricity seems to confirm the discoverer's suspicion that this object is of a cometary nature and it therefore receives the designation 1940 *a*. The object is and remains so faint that probably very few further observations will be obtained. Information about this object reached the writer with some delay while he was stationed at the McDonald Observatory in Texas. A couple of plates

taken at the prime focus of the 82-inch reflector on the computed region for the comet on April 1 and 3 did not reveal the presence of the object although stars down to 19th magnitude were recorded. A faint asteroid near the computed position proved to have a different motion so no confirmation came from that side.

There are no other known comets under observation at this time, nor are any expected in the immediate future.

Williams Bay, Wisconsin, April 16, 1940.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

The Rotation Period of Eros: Mr. Masaaki Huruhata, a research assistant at Harvard, has just completed a highly important discussion of the rotation period of the variable asteroid Eros. Although light-variation periods had been derived by Bailey, Taffara, Graff, and Campbell, there were still a few small deviations from the adopted period. Taffara explained these fluctuations as the effects of the changing aspect of the asteroid with reference to the sun and the earth.

Mr. Huruhata has studied the rotation-period of Eros in its relation to the light variation between the years 1900 to 1938, using over 500 observed minima. The problem involved corrections to the observed times of minima (1) for distance of Eros from the earth, (2) for change in direction of Eros about its axis as seen from the earth, and (3) for the relative positions of the sun, Eros, and the earth.

Huruhata concludes that the true rotation-period of Eros is $5^h\,16^m\,4^s.012 \pm 0^s.005$. This value is eight seconds smaller than Campbell's and Graff's light-variation period, and three seconds larger than the period derived by Taffara. If we are to judge by the small value of the probable error, $0^s.005$, it would appear that the value of the rotation period of Eros has now been definitely established.

The R Coronae Borealis Variables: Always of interest to variable star observers is the behavior of the R Coronae Borealis stars, especially when they are below normal maximum magnitude. Beginning in the summer of 1938, three of the four variables of this class have passed through minimum; first SU Tauri, then R Coronae Borealis itself, and lastly RY Sagittarii. SU Tauri, according to the Mount Wilson observers, decreased to the seventeenth magnitude and immediately began its steady, uniform increase to maximum which was attained in November, 1938. Far different was the activity displayed by R Coronae Borealis which has only now—April, 1940—reached nearly normal maximum magnitude. Diagrams illustrating the light variations have appeared in recent "Notes on Variable Stars." To bring the data up to the present time the accompanying table contains the five-day means of the observations made since the summer of 1938. Besides the mean Julian day are given the number of observations made in that interval and the mean magnitude to hundredths, where more than one observation was secured. More than 1800 observations are included in the table; those means toward the end show more irregularity than the others because of the scarcity of observations and the proximity of the star to the sun.

Mean J.D. 242+	No. Obs.	Mean Mag.	Mean J.D. 242+	No. Obs.	Mean Mag.	Mean J.D. 242+	No. Obs.	Mean Mag.
9150	15	5.98	9350	12	9.42	9525	18	11.75
55	20	6.03	55	8	9.13	30	7	11.81
60	23	6.10	60	11	8.95	36	4	11.08
65	49	6.21	65	30	8.74	40	23	10.84
70	30	6.33	70	19	8.67	45	26	10.04
75	54	7.54	75	39	8.63	50	34	9.69
80	41	8.53	80	19	8.56	55	32	9.23
85	52	8.19	85	11	8.42	60	12	9.05
90	63	7.67	90	30	8.32	65	13	8.69
95	58	7.82	95	49	8.39	70	23	8.63
9200	42	8.60	9400	36	8.59	75	20	8.67
05	25	9.83	05	26	8.65	80	31	8.39
11	6	11.37	10	22	8.73	85	15	8.11
15	15	11.95	15	13	8.65	92	4	7.47
20	4	12.52	20	33	8.76	95	11	7.85
26	1	12.8	25	25	8.80	99	1	7.0
28	1	13.4	30	37	8.88	9605	3	7.33
35	3	13.40	35	20	8.80	27	1	7.0
50	1	13.3	40	16	8.93	35	2	6.70
53	1	13.0	45	15	8.94	42	1	6.2
60	2	12.90	50	30	9.06	51	1	6.7
64	2	12.90	55	42	9.15	55	1	6.1
84	1	12.3	60	34	9.34	60	4	6.60
92	1	12.0	65	43	9.55	65	7	6.57
94	2	11.80	70	15	9.72	70	2	6.35
9300	2	11.40	75	10	9.65	75	6	6.35
07	3	11.13	80	35	9.67	80	2	6.25
10	11	11.21	85	50	9.63	85	5	6.30
15	6	10.78	90	35	9.77	90	4	6.05
20	7	10.19	95	23	9.98	94	3	6.17
25	2	10.45	9500	18	10.08	9700	12	6.38
31	2	10.20	05	16	10.62	05	3	6.47
35	10	9.98	10	22	10.69	12	2	6.50
40	15	9.56	15	24	10.89	16	3	6.07
45	32	9.47	20	33	11.64	21	1	6.6

There is little doubt that the star is irregular; and observers who are closely following it will be interested to find out how long the variable remains at maximum, whether for a few months or for a few years, or for ten years or more as happened between 1924 and 1934.

RY Sagittarii, another variable of the same class, underwent irregularities in light even more capricious than did R Coronae Borealis in the same interval of time. (See these notes for December, 1939.)

S Apodis has remained at normal maximum, 10.0, since 1935, and should be carefully observed in order that the drop to minimum, once it begins, may be fully noted. This variable, because of its far southern location, can be observed only in the southern hemisphere.

It might be desirable to place other variables of the R Coronae Borealis class on the A.A.V.S.O. observing list, such as RS Telescopii, RT Normae, and UW Centauri—to mention a few of the brightest and most interesting among them.

These well-named cataclysmic variables are doubtless giant stars. Their spectral types range from G to K and include class R; and the most prominent spectral feature is the strong indication of carbon compounds as compared with average stellar atmospheres. Berman and O'Keefe have suggested that the presence of an excessive amount of carbon may be largely responsible for the sudden diminution

in light and for the irregular variation displayed in their recovery to normal maximum conditions.

The Irregular Variable BM Scorpii: A recent Riverview College Observatory Publication (Vol. 2, No. 5) contains some interesting observations of BM Scorpii by Dr. J. Voûte. The photographic observations, obtained both at Lembang, Java, and at Riverview, New South Wales, reveal a generally irregular variation in light with a semblance of a five-year periodicity between minima—1929, 1934, and 1939. Fortunately M. F. Jordan had observed the variable on Harvard plates covering the years 1901 to 1923 and, although the five-year periodicity is not so marked as that shown by the 1929-1939 observations of Voûte, there is a suggestion of such a period.

Voûte finds a photographic range in light between $6^{M}.9$ and $8^{M}.8$. The Harvard plates show a variation between $7^{M}.0$ and $9^{M}.2$. The difference in range may be due to a difference in the adopted scales. The variable has been classified as of spectral class K. From the observations available it is difficult to decide to what type of variation the star belongs. Some of the features correspond to those of DF Cygni; also, many of the characteristics of Z Andromedae seem to be present. It should be another good star for visual observers to follow.

Current Observations of Novae: The A.A.V.S.O. observations of novae reveal some interesting facts regarding their present status, which have been summarized in the following table:

Design.	Name	Present magnitude	Remarks
032443	Nova Per, 1918	12.6	Fluctuating between 12.3 and 13.0.
053609	Nova Ori, 1939	9.2	Only slightly fainter than in January, 1939.
063462	RR Pic, 1925	9.8	Decreasing very slowly.
064001	Nova Mon, 1939	10.0	Decreasing gradually.
090031	T Pyx, 1890	[13.5	Recurrent type; no max. since 1920.
155226	T CrB, 1866	9.8	Practically constant.
174406	RS Oph, 1898	11.4	Recurrent type; last max. 1933; fluctuating between 10.5 and 11.1.
180445	Nova Her, 1934	10.0	Decreasing gradually.
184300	Nova Aql, 1918	11.0	Fluctuating between 10.5 and 11.5.
221255	Nova Lac, 1936	13.8	Decreasing gradually.
232848	Z And, 1901	8.6	Not much change in light since max. in 1939.

The Toronto Meeting of the A.A.V.S.O.: At the invitation of the Toronto Section of the Royal Astronomical Society of Canada, the 1940 Spring meeting of the American Association of Variable Star Observers will be held at the University of Toronto on May 31 and June 1. This will be the first meeting of the Association to be held outside the United States and it is hoped that the attendance will be large and representative.

Herbert C. Wilson: Those who can recall the beginnings of the A.A.V.S.O. will be saddened at the news of the death of the last of the trio who were responsible for its birth and organization—Professor Herbert C. Wilson. It was due to the initiative of Wilson, E. C. Pickering, and William Tyler Olcott that the program of variable star observing was begun in 1911. Wilson, then editor of Popular Astronomy, offered his services toward publishing the observational results, a vital necessity in the encouragement of amateur observers; Pickering offered the facilities of Harvard Observatory in supplying star charts and magnitudes; and Olcott undertook the arduous duties of secretary in collating the observations and maintaining the "esprit de corps" among the observers then scattered over the

entire country. Professor Pickering died in 1919, Mr. Olcott in 1936, and Professor Wilson, although he retired as director of Goodsell Observatory and editor of POPULAR ASTRONOMY in 1926, retained a keen interest in the A.A.V.S.O. until his death in March of this year. As one of the founders and as an honorary member of the A.A.V.S.O., Professor Wilson will long be remembered for the important part he played in amateur variable star observing thirty years ago.

Observers, and Observations Received, during March, 1940:

Observer	Var.	Obs.	Observer	Var.	Obs.
Albrecht	24	24	Loreta	183	727
Baldwin	69	198	Lundquist	24	113
Ball, A. R.	18	18	Maupomé	88	90
Ball, J.	15	15	McPherson	17	17
Bappu	30	68	Moore	1	1
Blunck	5	5	Needham	1	1
Bouton	2	2	Palo	23	36
Britzelmeyer	5	13	Parker	13	13
Carpenter	13	13	Peltier	21	37
Chilton	2	2	Prinslow	3	3
Cousins	24	50	Purdy	13	19
Diedrich	10	16	Rense	38	38
Ensor	18	18	Rosebrugh	18	87
Escalante	57	77	de Santis	18	26
Fernald	41	67	Saxon	9	9
Gregory	132	224	Schoenke	10	13
Griffin	17	17	Sill	14	14
Halbach	24	34	Smart	2	2
Harris	46	46	Smith, F. P.	5	7
Hartmann	129	192	Thorne	3	3
Holt	127	402	Topham	50	50
Houghton	69	96	Walton	16	25
Houston	20	53	Webb	18	18
Howarth	18	19	Weber	17	17
Kelly	22	30	Yamada	5	22
Klaire	4	4	Yamasaki	22	23
de Kock	61	215		—	—
Kozawa	16	42	Totals	54	3371

April 12, 1940.

Notes from Amateurs

New Haven Amateur Astronomical Society

Dr. Frank Schlesinger, Director of Yale Observatory, addressed the New Haven Amateur Astronomical Society at the March meeting on the subject "Some Astronomers I Have Known." The first astronomer Dr. Schlesinger mentioned was Lewis Morris Rutherford (1816-1892), who was born in New York City, and who was one of the wealthiest men of that city. He studied law and practised it for a few years, but early in life turned to astronomy and became the leading pioneer in the application of photography to that science. He built a fine observatory at the rear of his residence on Second Avenue and 11th Street. He first tried to photograph with a 12-inch visual telescope, but soon saw that the lens had to be figured especially for photography. He proceeded to make such a lens 11 inches in aperture, and afterward another of 13 inches. This latter is still in use at Columbia Observatory, to whom Rutherford left it in his will, together with a fine

collection of original negatives of the moon, the solar spectrum, and especially of star clusters.

George William Hill (1838-1914) was the next astronomer to be discussed. He too was born in New York City, but when he was a young boy his family moved to West Nyack, New York, then Nyack Turnpike. His father, and afterwards his eldest brother, combined farming with portrait painting in oils. George attracted the attention of one of his school teachers who induced his family to send him to college. Accordingly he went to Rutgers College where he fortunately came into contact with Professor Strong who directed the great mathematical abilities of his student to celestial mechanics. Hill worked for a while in the Nautical Almanac Office at Washington but resigned at the age of 54 to retire to his brothers' farm at West Nyack. He taught celestial mechanics for a time at Columbia University, refusing to accept the stipends for the last two years of this service because his students had been too few.

Edward Emerson Barnard (1857-1923) was born at Nashville, Tennessee. He began his astronomical career as a discoverer of comets, and built a house with the $100 prizes for such discoveries awarded by Mr. Warner, manufacturer of Warner's Safe Cure. Barnard was called to the Lick Observatory among the members of its first staff and greatly distinguished himself and the Observatory by his discoveries. He afterwards joined the Yerkes Observatory when it was established in 1896 and died there twenty-seven years later after a most inspiring career.

A life-long friend of Barnard's was S. W. Burnham (1838-1921) who was for many years Clerk of the Chicago Federal Court, devoting his nights after busy days to the discovery and measurement of double-stars. He too joined the Lick staff when that observatory was founded in 1888, and he too resigned to resume his Clerkship and also to spend two nights each week in observing with the Yerkes refractor. He was a man of slight build but of remarkable vigor, continuing to observe through his 75th year all night in the inclement Wisconsin winters. He is best known for his great Catalogue of Double Stars.

Seth Chandler (1846-1913) was for a time assistant at the Harvard Observatory, but he resigned to become an insurance actuary. Later in life, after he had amassed a competence as an actuary, he turned again to astronomy as an amateur, and is best known for his investigations concerning variable stars, and for his studies of variations of latitude.

All of the astronomers referred to by Dr. Schlesinger were, for a portion of their careers at least, amateurs of the science.

April 10, 1940. F. R. BURNHAM, *Secretary.*

Equatorial Drive from Electric Clock

Synchronous motors of the kind used in electric clocks, and many other recording and timing devices, furnish ample power to drive amateurs' equatorial telescopes of more than average dimensions. The torques of the various types of Telechron motors are 0.125, 0.375, 0.9, 1.0, 1.8, and 2.0 inch-pounds reckoned at 1 R.P.M. (revolution per minute), the two lowest values applying to clock motors of 2 and 4 watts input. The torque of the single type Hansen Synchron motor is about ½ inch-pound at the same speed. Theoretically a torque of one inch-pound at 1 R.P.M. is equivalent to a force of 359 pounds available to turn the polar spindle when applied at a distance of 4 inches from the axis, and in inverse ratio for other distances. In practice this value is unattainable, but can be approached closely with accurate workmanship.

If the Synchron motor is selected, it may be well to specify in ordering it that it be furnished without pinion attached. Otherwise the pinion will have to be removed, a delicate operation involving the risk of damage to the motor.

Other types of clock motors may prove satisfactory, but data are not at hand for any of them. In some of the cheapest grades of clocks the motor is not protected from dust, other injurious matter, and deterioration of lubricant.

The disadvantage that the motors function at standard time rate can be overcome by connecting the motor with the polar axis through a suitable train of 3 pairs of gear-wheels revolving on parallel axes, known to the trade as *spur-gears,* and a gear-screw meshing with a gear wheel of oblique teeth and concave face, known as *worm* and *worm gear.* Less than 3 pairs of spur-gears are not advisable, if the size of gear teeth is to increase gradually, as it should, from motor to polar axis.

The Telechron motor consists of self-starting rotor armature and gear-train enclosed in a sealed metal case held firmly between the poles of the stator field. The arbor of the last gear, or *terminal shaft,* projecting through the wall of the case for the transmission of power, revolves at 1, 2, 4, or 60 R.P.M. The Synchron motor is of somewhat different construction, self-starting, protected by metal case, and with 1 R.P.M. terminal shaft. If the motor only is purchased, the terminal shaft should be of 1 R.P.M. speed to avoid the necessity of additional gearing, but, if a clock is used, the terminal shaft may be of any speed. The additional gearing, if required, is part of the clock, and the power is taken from the arbor that carries the seconds hand, to be considered as the terminal shaft. The required train of gears then is to be designed to change the time of one revolution from one standard minute to 24 sidereal hours, or $23^h\ 56^m\ 4^s091$ of standard time.

If the distance between the axes of two meshing spur-gears is divided in two sections in the same proportion as the numbers of teeth, each section is the radius of the *pitch circle* of its respective gear. The *circular pitch* is the distance between the active faces of adjacent teeth measured on the pitch circle. The *diametrical pitch* is the number of teeth per inch of the diameter of the pitch circle. Standard gears are classified according to diametral pitch, mainly because it is in the form of an integer or a simple fractional number as 1½ or 2½, while the circular pitch is an incommensurable number for all standard gears in any system of mensuration. Knowledge of this pitch, however, is useful in selecting the best diametral pitch suitable for a given purpose, when it should be kept in mind that the circular pitch is the thickness of the tooth plus the width of the space.

The following table is a comparison of the two pitches, the approximate value of the circular pitch both in inches and in millimeters for greater facility of visualization.

D.P.	——C.P.——		D.P.	——C.P.——		D.P.	——C.P.——	
	Inches	Mill.		Inches	Mill.		Inches	Mill.
1½	2.0944	53.2	5	0.6283	15.96	16	0.1963	4.99
2	1.5708	39.9	6	0.5236	13.30	20	0.1571	3.99
2½	1.2566	31.9	8	0.3927	9.97	24	0.1309	3.325
3	1.0472	26.6	10	0.3142	7.98	32	0.0982	2.494
4	0.7854	19.95	12	0.2618	6.65	48	0.0654	1.6625

If the circular pitch is expressed in inches, the product of the two pitches is π. So if π is divided by one pitch, the quotient is the other pitch. The diameter in inches of the pitch circle of spur and worm gears is the number of teeth divided by the diametral pitch. The overall diameter is the number of teeth $+2$ divided by the same pitch. Inversely, the diametral pitch is the number of teeth divided by

the diameter in inches of the pitch circle, or the number of teeth +2 divided by the overall diameter. For worm gears these rules apply to the median plane. The overall diameter at the edges is slightly larger.

When not specified, the word *pitch* is always understood to mean diametral pitch.

The following list contains the numbers of teeth of all standard spur-gears made in the two largest gear manufacturing plants of the United States, in the pitches suitable for equatorial drive of amateurs' telescopes of all sizes. As several gears made by one firm are not made by the other, it is possible, but doubtful, that other firms may manufacture standard spur-gears not included in this list.

Pitch	Numbers of Teeth
10	12 13 14 15 16 18 20 all numbers 21 to 99 both incl. 100 105 108 110 112 120 130 140 144 150 160 162 176 180 192 200
12	12 13 14 15 16 18 20 all numbers 21 to 119 both incl. 120 126 132 144 156 168 192 216 240
16	12 13 14 15 16 18 20 all numbers 21 to 127 both incl. 128 140 144 156 160 180 192
20	12 13 14 15 16 18 20 all numbers 21 to 119 both incl. 120 128 132 135 140 144 150 156 160 180 200
24	12 14 15 16 18 20 21 24 28 30 36 40 42 45 48 54 56 60 66 70 72 84 96 108 120 144
32	12 14 15 16 18 20 22 24 26 28 30 32 36 40 44 45 48 52 54 56 60 64 72 80 88 90 96 112 128 144 160 192
48	12 14 15 16 18 20 22 24 26 32 36 40 44 45 48 54 60 66 72 80 84 96 100 120 144 192

Standard spur-gears are made with less than 12 teeth, but they have been omitted as not adapted for uniform ratio of angular velocities.

The ratio of one standard minute to 24 sidereal hours, mentioned in a preceding paragraph, is expressed by the fraction 1/1436.06818333... If a gear train can be constructed according to this ratio without error, it would be prohibitive in cost and dimensions, and would also be a superfluous refinement. The frequency of the electric current, although constant on the average, is subject to slight fluctuations of rate, and the motion of celestial objects is not exactly uniform, owing mostly to atmospheric refraction. In accord with these considerations, the investigation has been based on the assumption that a combination of gear ratios is sufficiently approximate, if the error does not exceed 3 seconds in 24 hours. Several such combinations have been found, the following being the most accurate and fortunately the most practical, although the investigation was not carried quite to exhaustion, which was considered unnecessary in view of the close approximation of the results obtained thus far, and good reasons to expect that they could not be bettered.

Gear Ratios				Combined Ratio	Error
14/18	15/66	26/66	1/100	1/1436.04396	$-0^m02432 = -1^s459$
24/60	28/66	26/66	1/96	"	"
12/14	25/63	26/127	1/100	1/1436.07692	$+0^m00874 = +0^s524$
26/56	32/56	32/127	1/96	"	"

The fractions represent pairs of meshing gears, the numerator being the number of teeth of the driving, and the denominator that of the driven gear. The first numerator gear is mounted on the terminal shaft of the motor. A denominator gear and the following numerator gear are mounted on a common arbor. The last fraction is for worm and worm gear, the worm gear to be mounted on the polar axis.

A worm is equivalent to a spur-gear of 1, 2, 3, 4, or 8 teeth, designated as

single thread, double thread, etc. Single thread worm and worm gear only are to be used in this train. The others are not suitable mechanically for this special purpose. Standard single thread worm gears of 100 teeth are available in the 6, 8, 10, 12, 16, 24, 32, and 48 pitches, and of 96 teeth in the same pitches except 10. Less than 96 teeth are not recommended for the worm gear, and 100 are preferable.

Excluding the last fraction, which must not be displaced, and should not be other than 1/100 or 1/96, the other fractions may be changed by transposition, multiplication, division, or any other process, providing that no change is made in the ratio of the product of the numerators to the product of the denominators. This principle has been applied in deriving the second combination from the first and the fourth from the third, in order to provide a wider choice of gears. In making such changes, it will be worth while bearing in mind that the numbers of teeth of standard gears contain no higher prime factor than 13, except in the 10, 12, 16, and 20 pitches, where all numbers are included within certain limits, as noted in the list.

Although the third and fourth combinations are more nearly accurate, they are less suitable for small telescopes on account of the gear of 127 teeth, which is available only in the 16 pitch. It is possible, but not probable, that this gear may be carried as standard in some of the finer pitches by other manufacturers than those referred to above. It may be made to order, but the cost will compare with that of a spur-gear of similar dimensions in the ratio of approximately 6 to 1.

The current practice is to make gears with involute teeth. Two of the properties of such teeth are that a change of distance between axes of meshing gears does not affect the ratio of angular velocities, and that the *backlash*, or clear space between the idle faces of the teeth, decreases with decrease of this distance. Gears are finished to a very high dgree of accuracy by reliable manufacturers, and if the rest of the apparatus is constructed with like accuracy, the idle faces of the teeth can be brought to a sliding contact without excessive friction. This condition is essential between worm and worm gear to prevent loose motion in the polar axis, but it is not important in the other gears, because the worm gear cannot drive the worm. When the telescope is unclamped and moved by hand, it may increase the load on the motor by increased frictional resistance between worm and worm gear, but while the motor is running, the active faces of the teeth of the spur gears will always be in contact, irrespective of any amount of backlash between the idle faces.

In addition to a close fit between worm and worm gear, the worm must be restrained from longitudinal motion. One or both bearings may be made adjustable, or the arbor may be provided with two collars held in place by set screws and located on both sides of one bearing.

If excessive weight of moving parts or sluggish bearings or both should necessitate the use of two motors, they should be self-starting, identical in every detail and connected through the same switch in order to distribute the load equally at all times and prevent overloading one of the motors.

If the telescope is already equipped with worm gear of a number of teeth other than 100 or 96, the writer offers to calculate the most practical combination of spur-gears, but there is no assurance that they will be all standard gears and of suitable pitches.

Standard gears are sold by commercial firms in most of the leading cities of the United States and Canada. It may be necessary to apply to more than one of such firms to obtain all the gears required, their general practice being to carry the stock of only one manufacturer.

D. F. Brocchi.

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The Herschel Astronomical Club

The Herschel Astronomical Club of Fall River, Massachusetts, now meets once a month at the homes of its members. It was formed in 1935, at which time several radio broadcasts and public meetings aroused an interest in astronomy in this community. When the entertainment phase was over, and serious discussions began, there remained a small group which has kept the society active ever since.

We are well supplied with optical aid, having three 4-inch refractors, one 3-inch refractor, a 4-inch RFT reflector, and two others now under construction. Three of our members who belong to the A.A.V.S.O. supply us with lantern slides from the fine Harvard Collection to illustrate our lectures.

Our president is Mr. Samuel R. Parks, instructor in Science at a local school.

FRANK J. KELLY, *Secretary*

Fall River, Massachusetts, April 15, 1940.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

The Asteroid

The vast array of twinkling stars, the brilliant trail of the meteor, the bearded comet—all present a magnificent spectacle. The most indifferent mind is attracted heavenward, the most unimaginative persons dream, because these phenomena are visible. They force themselves on our fancy. We cannot help seeing them. Few of us know that the greatest celestial mysteries are invisible. Who has seen Eros? Who has seen the thousands of its tiny companions, midget worlds which in addition to the greater planets travel around the sun? Eros is more puzzling than Mars. Nothing is known about it, except that its diameter cannot exceed twenty miles.

These dwarfs of the Solar System occupy a wide area between Mars and Jupiter. Because their orbits resemble comet-paths, many of them travel into close proximity with the earth. Eros comes within 14 million miles of us—an extremely short distance, astronomically speaking. Only one other body is ever nearer, and that, the moon.

The largest of the asteroids (these midget worlds) is 480 miles in diameter. Others hardly exceed twenty; while the majority of them, probably, are no larger than boulders.

With regard to shape, the asteroids are generally considered fragmentary rather than spherical. Remarkable changes in brilliancy indicate that they may be triangular in some cases or dumbbell shaped; and that from time to time they present greater or lesser portions of their surface toward us. Eros' changes are so extreme that astronomers believe regions of its surface are highly reflective—perhaps composed of aluminum.

The most interesting question which confronts the astronomer about these Lilliputian worlds is, "Whence did they come?" Could they be the fragments of a single world which in ages past met disaster? A planet bursting to pieces! It

seems impossible. Nevertheless there are forces in the Universe powerful enough to destroy whole systems of planets.

It is interesting to imagine that if such a world did exist, it may have sustained life. Civilization may have flourished on its surface. Ages of progress may have produced among its people a Utopia. . . . Then suddenly some titanic power breaks its fetters, and raging and howling it cracks the world in a million places. Explosion after explosion rends the swiftly vanishing atmosphere. Tremendous heat instantly vaporizes the oceans. The planet's attraction gives way, and the world bursts into countless fragments.

This theory of the origin of the asteroids, although it holds some credence, is now generally disproved because many astronomers believe it does not fulfill certain technical requirements. Following is the more popular theory: billions of years ago, the sun and the Solar System formed an immense whirling mass of gaseous substance—a nebula. Due to the rapid whirling and pliability of the nebula's material, rings of matter were thrown off. These condensed into balls, and the balls solidified forming the planets as we know them today. The giant Jupiter was formed in this manner; but when the nebula threw off the next ring, Jupiter's powerful attraction prevented it from forming a single planet. Instead it condensed into hundreds of tiny worlds—the asteroids.

RUFUS O. SUTER, JR.

Is This Why Variable Stars Vary?

After having been asked a number of times as to what caused some stars to vary in brilliance, the writer of this article began to probe around to find out what theories are most generally accepted. In the course of investigation, three major theories were found. First, there is the pulsation theory, which relates the long-period variables to the Cepheids, and attributes the changes in luminosity to periodic changes in the star's diameter. Secondly, there is Eddington's theory that the fluctuations in magnitude are due to periodic outbursts of a continuously luminous star; that minimum light is the normal condition of the variable, and that long-period variables are closely allied with the SS Cygni type (See Tables 1 and 2). Thirdly, there is the theory expounded by Dr. Paul W. Merrill, that the variations are due to the periodic accumulation of opaque clouds in the outer atmosphere of the star and the dispersal of this veil by accumulated heat from within the star.

After cogitating on these three theories, the writer has chosen as the most probable one the first or the Pulsation Theory for the following reasons: First, some of the better observed long-period variables show variable radial velocities of the same type observed in Cepheids. Secondly, there is a similarity between the light curves of the Cepheids and the Mira type or the long-period variables. Thirdly, the long-period variables follow the period-spectrum relation, at least among the Me-type stars. Fourthly, only the pulsation theory permits the calculation of a theoretical luminosity curve. Lastly, this theory fits into the one given in this article. Other arguments in favor of this hypothesis are: that the long-period variables seem to link on to the RV Tauri type. The fact that the difference between the long-period variables and the Cepheids, particularly those Cepheids with periods of 30 days or more, is slight compared with the difference between the long-period variables and the SS Cygni type.

The real problem of this theory is just what causes the expansion and contraction of such giant bodies. To actually conceive what immense forces cause such physical changes, we will put forth, for the purpose of elucidation, a hypothetical case.

Imagine a giant star such as Antares (α Scorpii), whose diameter is some 210,000,000 miles, being variable. What forces could cause this giant sun to expand and contract at all, much less in a regular period? Yet if this theory is correct it is possible that such giant stars as Antares can be variable. According to Noah W. McLeod of Christine, North Dakota, "If the diameters of RU Virginis and S Aurigae be computed from their absolute magnitudes as read from the period-luminosity curves, their diameters come out larger than the orbit of Saturn. The diameter of RU Virginis comes out 2,280,000,000 miles; that of S Aurigae as 1,810,000,000." This conclusively proves that our hypothetical case is not beside the point in that such giant bodies, even larger than Antares, are variable.

If sunspots actually play a part in the change in the size of these stars, the following theory may not be entirely off. It may contain a good percentage of truth and it is certainly evident that it is possible. In this article I shall attempt to explain by my theory classes 1 to 5, inclusive, in the list of variable star classes.

TABLE I

VARIABLE STAR CLASSES AND THEIR TYPICAL STARS

No.	Class	Typical Stars
1.	New or Temporary Stars	Nova Persei, Nova Aquilae, etc. . .
2.	Nova-like stars	η Argus, T Pyxidis, etc. . . .
3.	R Coronae stars	R CrB, RY Sgr, SU Tau, etc. . . .
4.	SS Cygni stars	SS Cyg, U Gem, SS Aur, etc. . . .
5.	Mira stars (ο Cet)	ο Cet, χ Cyg, R Leo, etc. . . .
6.	μ Cephei stars	μ Cep, α Ori, ρ Per, etc. . . .
7.	RV Tauri stars	RV Tau, R Sgr, R Sct, etc. . . .
8.	Long-period Cepheids	δ Cep, α UMi, ζ Gem, etc. . . .
9.	Short-period Cepheids	RR Lyr, RR Cet, XX Cyg, etc. . . .
10.	Eclipsing stars (Algol type)	β Per, λ Tau, ε Aur, etc. . . .

TABLE II

EXPLANATION OF TYPES*

1. New or temporary stars.
2. Stars whose fluctuations suggest that of the nova type, etc.
3. Stars usually at a constant maximum, with occasional sharp minimum.
4. Stars usually at a constant minimum, with occasional sharp maxima.
5. Range of several magnitudes, fairly regular periods from 100 to 600 days.
6. Red stars with irregular variations of a few tenths of a magnitude.
7. Stars having usually a secondary minimum between successive primary minima.
8. Regular periods of one to 45 days. Range about 1.5 magnitudes.
9. Regular periods of less than one day. Range about one magnitude.
10. Very regular periods. Variations due to covering of primary star by its companion or companions.

*I have used Ludendorff's classification taken from the *Handbook of the Royal Astronomical Society of Canada*. The type stars were chosen by the writer.

MIRA OR TYPE 5 STARS

Our sun is a variable star and one of the suspected causes for its variation is sunspots. Now the sun has a regular period of rotation on its axis which it follows; though this period varies with the distance from the equator, the period at the poles being 10.1 days longer than at the equator, according to a series of observations made by Plaskett and DeLury. Since the sun is a small star and therefore the average variable is hundreds and even thousands of times larger than that orb, there is a much longer period of rotation on its axis (see Table IV for comparative sizes).

We will take χ Cygni, which is a No. 5 type star (see Tables I, II, and III) as an example. It has a period of 406.6 days. Might we not suppose that this is the period of that star's rotation on its axis? If so, then the cause of expansion and contraction might be explained in that way.

While there are sunspots scattered all over the surface of χ Cygni, there is one central place of disturbance. That is a portion on the surface where there are periodical eruptions from within that star. An eruption starts and gains force, an eruptive prominence forms and the flames and gases are forced away from the body by the force of the eruption. Since the flames on the sun have been known to leap more than half its diameter (440,000 miles) out into space, thus if the flames and prominences of χ Cygni should leap out into space in this same proportion the apparent size of that orb would thereby be increased.

TABLE III

DATA ON TYPICAL STARS

Name	Design.	Max.	Min.	Spectrum	Period	Type
N Aql	184300	—0.2	10.9	Q	Irr.	1
η Arg	*104259*	—1.0	7.8	Pec.	Irr.	2
R CrB	154428	5.8	15.0	G0e	Irr.	3
RY Sgr	*191033*	6.5	11.5		Irr.	3
SU Tau	054319	9.5	15.4	G0e	Irr.	3
SS Cyg	213843	8.1	12.0	Pec.	Irr.	4
U Gem	074922	8.8	13.8	Pec.	Irr.	4
o Cet	*021403*	2.0	9.6	M5e	331.6	5
χ Cyg	194632	4.2	13.4	M7e	406.6	5
R Leo	094211	5.0	10.5	M7e	313	5
α Ori	054907	0.2	1.2	M2	Irr.	6
ρ Per	025838	3.3	4.1	M4	Irr.	6
RV Tau	044126	8.7	11.8	K0	78.60	7
R Sgr	200916	8.4	10.4	cG7	70.84	7
R Sct	*184205*	4.5	9.0	K5e	141.5	7
δ Cep	*222557*	3.6	4.3	G0	5.36640	8
α UMi	012288	2.3	2.4	cF7	3.96815	8
ζ Gem	065829	3.7	4.1	cG1	10.15353	8
RR Lyr	192242	7.1	7.8	A5	0.56684	9
RR Cet	012700	8.4	9.0	F0	0.55304	9
XX Cyg	200158	11.4	12.1	A	0.13486	9
β Per	030140	2.3	3.5	B8	2.86731	10
λ Tau	035512	3.8	4.2	B3	3.95294	10
ϵ Aur	045443	3.3	4.1	F5p	9900.00000	10

Now the heat from the core of χ Cygni would illuminate this projected matter, thus not only increasing its apparent size but also its brilliancy. Then when the eruption begins to dwindle, the force of gravitation on this immense body would draw this expelled material back towards the main body, thus giving an apparent decrease in size and brilliancy. While we would not be able to see the fluctuation in diameter, we would be able to see the changes in brilliancy.

IRREGULARITY AT MAXIMUM AND MINIMUM

Now the range of fluctuation of the variable cloud would be governed as follows: If the eruption was of great intensity, the maximum would be brighter than when an eruption of not so great an intensity came, due to the following facts:

1. When a major eruption takes place, more matter and gases are thrown out than when a minor one comes. 2. The force from a greater eruption would throw the expelled material farther out into space than a minor one, thus giving a larger apparent diameter and hence a greater brilliance than at a secondary or minor

eruption. The size and intensity would control the fluctuations in apparent diameter and brilliance. Consequently the same conditions would govern the minimum. Suppose that a major maximum had been reached, after that the pressure lessens rapidly and the gravitation from the star draws the expelled material back toward the star, causing a decrease in apparent diameter and briliance, the minimum being controlled by the amount of decrease in the intensity of the disturbance.

The irregularity in maxima and minima can be easily shown by several examples. 1. o Ceti (Mira or type 5) may have a maximum varying from the first to the fourth magnitude, while some variables have a minimum varying several magnitudes. A notable example to date is that of R Aquarii, whose maximum magnitude is 6.0 and the minimum is 10.8 with a period of 387 days. This variable has not reached a maximum brighter than 8.2 and a minimum fainter than 9.2 since 1928, a period sufficient to allow it to complete three or more ranges of its magnitude and period. (*Harvard College Variable Star Bulletin* (*AAVSO*) for August-September, 1932.)

TABLE IV

SOME COMPARATIVE SIZES

——SOLAR——		——STELLAR——	
Name	Diameter (miles)	Name	Diameter (miles)
(Smallest Asteroid)	approx. 2½	α Centauri	432,196
Euterpa (Ast)	50	α Aquilae	605,074
Hygeia (Ast)	103	α Lyrae	1,037,270
Ceres (Ast)	196	α Aurigae	5,186,332
Vesta (Ast)	214	α Bootis	12,965,780
Moon	2,160	α Tauri	25,931,760
Mercury	3,009	β Pegasi	73,473,320
Earth	7,917.8	α Orionis	125,333,040
Neptune	32,932	α Scorpii	208,456,080
Jupiter	86,728	RU Virginis	1,810,000,000
Sun	864,392	S Aurigae	2,280,000,000

EXPLANATION OF THE BROAD AND NARROW TYPE MAXIMUM

The case of irregular variables such as SS Cygni, which have a broad and narrow type maximum, could be explained as follows: If on the surface of SS Cygni the movements of the sunspots are very eccentric and these said movements are progressive and retrogressive, this would cause the irregular period, as in SS Cygni, of 30 to 103 days.

Say also that from the nucleus of the eruptive center the spots radiate from it in the afore-named movements, namely, progressive and retrogressive, thus spreading the intensity, it would take longer to unify and to rise to a maximum than when not spread out. If these movements are in themselves irregular, the progressive movements at numerous intervals will be excessively strong and thus there is a closer relationship between the radiated spots and the nucleus of the eruptive center than when greatly radiated, hence the shorter period. When the eruption starts at the nucleus, the radiated matter will be drawn back to the eruptive center and the maximum forms as was described previously.

The rapidity of the maximum or the type will be governed by the number of radiated spots from the nucleus and their distance away from the eruptive center. The fewer spots away from the nucleus and their proximity to each other would facilitate a quick maximum. Whereas a great number of spots spread over a large area would take longer to unify, thus causing a slow rise to maximum and the longer period or the broad type, as for SS Cygni and other members of its class.

NOVA-LIKE STARS AND NOVAE

These types of stars require special consideration as they differ entirely from the other orbs in space that are variable. These two types of stars will be considered in Part II of this article to be published at a future date.

I hope that the readers of this article will take it at its worth, though this may be in the estimation of some individuals not worth very much. We all have times when we sit back and, reflecting deeply, endeavor to divulge to others in writing, our reflections regarding intricacies of some stellar phenomena. (Copyright 1932 by J. Wesley Simpson.)

J. WESLEY SIMPSON.

639 Locksley Place, Webster Groves, Missouri.

General Notes

Dr. Frederick C. Leonard, associate professor of astronomy at the University of California at Los Angeles, has been elected to life membership in the Royal Astronomical Society of Canada. (*Science,* April 5, 1940.)

Dr. Donald H. Menzel, of the Harvard College Observatory, addressed a joint meeting of The Franklin Institute and The Rittenhouse Astronomical Society of Philadelphia on Wednesday, March 6. Dr. Menzel's topic was "What is New in the Sun." He discussed the newer discoveries concerning the solar atmosphere, prominences, corona, sunspots, and their relation to solar variability. He also considered the effects of the sun upon the earth, including magnetic storms, aurora borealis, radio fade-outs, and the question of weather prediction.

Dr. Frederick C. Leonard, of the Department of Astronomy of the University of California at Los Angeles, gave a lecture on "Meteorites," illustrated with specimens from his collection and with lantern slides, before the Los Angeles Astronomical Society, at its headquarters, 2606 West Eighth Street, on the evening of April 11, 1940.

Ferdinand Ellerman, a member of the staff of the Mount Wilson Observatory from its establishment in 1904, died of pneumonia on March 20, 1940, at the Queen of the Angels Hospital in Los Angeles, California. With a heart in a somewhat weakened condition, his strength was insufficient to rally from an attack of influenza which developed rapidly into the more serious disease. His wife, Hermine Hoenny Ellerman, and daughter, Louise Ellerman Burnett, survive him.

Ellerman was born at Centralia, Illinois, on May 13, 1869, and received a high-school education. For a few years he was in the employ of a commercial firm in Chicago, where he acquired marked skill in photography and in the use of machine tools. Dr. George E. Hale, himself but one year older than Ellerman, was at this time organizing his private observatory at Kenwood in Chicago and, needing an assistant, offered the position to Ellerman. This was in 1892, and the relationship begun at this time continued for nearly half a century until Hale's death in 1938. (*Science,* April 5, 1940.)

The Rittenhouse Astronomical Society of Philadelphia held its regular meeting on Friday, April 12, 1940, in the Hall of The Franklin Institute. The evening was designated the Sproul Observatory Night. Three men from Sproul Ob-

servatory participated in the program as follows: Dr. John A. Miller—"The History of the Sproul Observatory"; Dr. K. A. Strand—"Photographic Measures of Double Stars"; Dr. Peter van de Kamp—"The Importance of Accurate Photographic Positions in Astronomical Problems."

The Philadelphia Section of The Institute of Radio Engineers, Incorporated, held a meeting on Thursday, March 7, 1940, at the Engineers Club, 1317 Spruce Street, Philadelphia, Pennsylvania. The speaker was A. M. Skellett, Bell Telephone Laboratories, Inc., his subject being "The Coronaviser, A Television Instrument for Observing the Solar Corona without an Eclipse." The problem of observing the solar corona without an eclipse has been attacked many times in the past by many different methods. It appears to be solved with the aid of a new instrument built at the Bell Telephone Laboratories and tested at the Cook Observatory, Wynnewood, Pennsylvania. The instrument, by using television technique and scanning the image of the sky around the sun, separates the coronal image from the glare in the sky by electrical filtering so the corona may be reproduced.

Astronomical Hospitality.—A cordial invitation has been extended to the members of the Rittenhouse Society to visit the following:

The Flower Observatory of the University of Pennsylvania, every Thursday evening—7:00 P.M. to 10:00 P.M.

The Sproul Observatory of Swarthmore College, second and fourth Tuesdays from 1:30 P.M. to 9:30 P.M.

The Strawbridge Observatory of Haverford College, first and third Fridays from 7:30 P.M. to 10:00 P.M.

Mr. Harry Rumrill's private observatory—at any time.

The Observatory and Planetarium of The Franklin Institute.

The Ladd Observatory Eclipse Expedition to Thomasville, Georgia

To make a photographic record of the annular eclipse of April 7, 1940, a party from Ladd Observatory, Brown University, travelled to Thomasville, Georgia. Three things were planned: the timing of the four contacts, a sequence of photographs with a camera eleven feet in focal length, and motion pictures of the eclipse with a 16 mm. camera equipped with an 18-inch lens.

Dr. C. H. Smiley and Arthur A. Hoag were to use the 11-foot camera. F. W. Hoffman was in charge of the motion picture program and Mrs. C. H. Smiley was responsible for timing, radio time signals, etc.

Through the courtesy of Mr. Stanley Upchurch, the instruments were mounted on the roof of the Upchurch Building, the tallest building in Thomasville. Test exposures made on Friday and Saturday showed the instruments in satisfactory adjustment. The party used the dark room facilities of the Thomasville *Times-Enterprise* through the kindness of Mr. Albert Feinberg.

On the seventh, the sky clouded over completely and shortly before the time of the first contact, 3:37 P.M., it began to rain. It continued to rain until the following morning. There was no opportunity to use the 11-foot camera with its excellent focal-plane shutter made especially for this eclipse by H. A. MacKnight and W. T. Grinnell. It was pleasant to hear by telephone that Miss Grace Harris and E. G. Gibson had successfully recorded the partial phase at Ladd Observatory.

The only photograph taken during the period of eclipse was a color photograph of some unusual clouds resembling those associated with tornadoes. It was

learned later that a tornado had struck in Chattahoochee, Florida, at 2:35 P.M., only about fifty miles away and in the direction in which the clouds had been seen.

The members of the party were disappointed in the weather but not in Southern hospitality. The many kindnesses shown them by the citizens of Thomasville and the beauty of the homes and gardens of the region created in them a desire to return.

CHARLES H. SMILEY.

Ladd Observatory, Brown University, April 17, 1940.

The Aurora of March 24, 1940

On March 24, 1940, occurred the brightest and most interesting display of the aurora borealis seen in some time. Not since the auroral exhibition of January 26, 1938, has this region seen the equal of the phenomena manifested on this date. Nearly two hours before noon-time on this day it became apparent, from reports filtering in from airports, newspaper offices, and telephone switchboards, that a severe magnetic disturbance was in progress. Reception of the usual high-frequency radio signals from European transmitters was practically impossible.

Routine observation of the sun at noon revealed little change with the exception of the normal movement of the two large spots which had been under observation for some days previously. The number of areas of faculae was perhaps slightly greater than usual.

At 6:34 P.M. the first signs of auroral light were certainly seen in the now rapidly darkening eastern sky as a very bright, elongated, ray of apple green which lengthened and shortened a few times and faded away. In a short time more streamers appeared and a low arch of rose and pale yellowish light erected itself in the north. Very thin, needle-like rays of greenish light now began to form in rows and gradually move toward the west, brightening and fading slowly as they moved. At times three separate and distinct arches were visible stretching from west to east. The predominating color at this time was white although there were many bright green areas scattered over the sky. The streamers were never still, but undulated while pulsations of light swept across them from east to west.

Only the brighter stars of the circumpolar constellations were visible through the shifting, glowing haze of light. At about 7:45 P.M. it was noted that the inner edge of the upper arch bent back upon itself and that the streamers above were arranged, apparently, in folds very like the folds of a heavy velvet curtain. The sky beneath this arch appeared blacker than the ordinary night sky, an effect which seemed too strong to be due merely to contrast. No stars could be seen in this black region although they were looked for in particular.

At several times during the display immensely long, narrow bands of pale blueish light extended from the lowest arch practically to the zenith. Moonlight detracted considerably from the brilliancy of the spectacle. Shortly after 8:30 P.M. clouds began to come up and by 9:00 P.M. only a bright spot behind the clouds marked the area of intense activity. By 10:45 P.M. the sky was again free from clouds but the intensity of the display was diminished by fully one-half. Only sluggishly moving hazy patches of light were visible and these soon faded away into the moonlit sky.

In general the display was of the coronal type, in which the auroral streamers extend upwards and converge at the zenith, forming a "crown" of light there. In this case, however, the "crown" was most imperfectly formed, almost nothing of the "umbrella-rib" formation being seen.

The spectrum of the aurora was seen here by several observers with a Brown-

ing pocket spectroscope. The usual bright line in the green was easily seen throughout the display, and when the brightest areas were observed at their maximum brilliancy three other lines or bands which were too faint to locate accurately were perceived in the blue or violet.

Although there was little of the wonderful rosy color which was predominant in the January 26, 1938, display, yet the auroral arches were unusually brilliant and the movements of the streamers most interesting. Had darkness fallen an hour or two earlier I am convinced the phenomena would have been much more striking. It is to be hoped that the new "coronaviser" recently built by the Bell Telephone Laboratories utilizing some of the principles of television and presenting the sun's coronal image on the surface of a cathode ray tube may prove capable of predicting when these magnetic "storms" are due to arrive.

LEWIS J. BOSS.

Seagrave Memorial Observatory, North Scituate, Rhode Island,
March 25, 1940.

Note on the Apparent Diameters of Star Images in Telescopes of Different Sizes

The statement is often made that a large telescope gives a smaller star image than a small telescope. Though this is true in one sense of the word, the form of this statement leads to a very generally accepted, but nevertheless erroneous, idea.

The resolving power of a telescope, or the radius of the first dark diffraction ring, is usually given in the following form:

Resolving power in seconds of arc = 4.5/Diameter of object glass in inches.

It is thus evident that an object glass of large diameter will give a star image of small *angular* diameter. But since the ratio of focal length to aperture is usually about fifteen to one for refractors, and in the neighborhood of eight to one for small reflectors, it is evident that the focal length of any given type of instrument will increase as the aperture increases. If the relationship used in radian measure, *i.e.*, the angle equals the arc divided by the radius, is applied to the star image, we find that the *linear* diameter of a star image equals the *angular* diameter of the image times the focal length of the telescope. Since for any two instruments having the same focal ratio the focal length would vary *directly* as the apertures it is evident that the linear diameter of the star image would be entirely independent of the size of the telescope. Thus, with the same eyepiece, a star image should look the same size in a 3-inch telescope of focal ratio 1:18 as it does in the 40-inch Yerkes refractor.

For the delineation of planetary detail, or the separation of close double stars, the important factor is the size of the smallest objects resolvable as compared with the apparent size of the planet or the separation of the two stars. Since this is a case of angular resolving power, the telescope of large aperture has an unquestioned advantage.

In order not to be misleading, therefore, our statement should be either "A large telescope gives a star image of smaller *angular* diameter than a small telescope," or else "A telescope of large focal-ratio (diameter of objective divided by its focal length) gives a star image of smaller *linear* diameter than a telescope having a small focal ratio."

THEODORE G. MEHLIN.

Drake University Municipal Observatory,
Des Moines, Iowa, February 7, 1940.

Book Reviews

Portraits of Famous Philosophers who were also Mathematicians with Biographical Accounts, by Cassius Jackson Keyser. (Scripta Mathematica, New York, 1939. Price $3.00.)

This collection contains a portrait and a short biography of each of twelve philosophers, all of whom, except Epicurus, were famous also as mathematicians. Keyser includes Epicurus because of that philosopher's use of the important mathematical concept of infinity.

The portraits are in black and white on single sheets of good paper, almost ten by twelve inches. It would be helpful if the information on the source of each had been furnished. Each one is enclosed in a four-page folder, a little larger than the picture, with a title page and three pages devoted to the life of the subject.

The portraits are from a wide range of sources and reveal a large sphere of artistic abilities. The best work of art in the collection is not an actual portrait, but merely the artist Raphael's conception of Pythagoras. In the portrait of Plato, taken from a statue in the Vatican, the simplicity and heavy ruggedness of the features characteristic of the golden age of Hellenistic art contrast with the flamboyancy in the two views of a statue of Aristotle in a Vienna museum which was produced in a decadent period of Greek sculpture. The portrait of Epicurus taken from a statue in the Metropolitan Museum reveals a stylized treatment in the hair and distortion of the length of the face. Again we have merely the conception of the artist in the full length Hope-Pinker statue of Roger Bacon in the Oxford University Museum. Descartes' portrait is from a steel engraving. The artist used an interesting full-length pose at a writing table, good chiaroscuro, excellent composition, but poor perspective. It is unfortunate that a better portrait of Spinoza was not obtained for the collection. This one is coarse and poorly composed. The well-known engraving of Leibnitz is good in texture and composition. That of Berkeley was boldly executed, but it is lacking in good composition. That of Kant shows a natural pose with a penetrating, scrutinizing gaze. Charles Peirce is represented by a clear photograph.

In the biographical accounts, of about twelve hundred words each, Keyser chose wisely from all the available source material to give an interesting sketch of the family history, education, interests, and accomplishments of each of the twelve great thinkers, in so far as these facts have been recorded. Because Pythagoras lived before the time of recorded history, the author mostly describes the Pythagorean school and shows how it influenced the following generations. Keyser is likewise handicapped in his sketch of Rober Bacon, who was not appreciated during his life time, his work being centuries ahead of his contemporaries.

It is gratifying that the author has seen fit to include the name of one American, Charles Sanders Peirce (1839-1914). His father, Benjamin, and his brother, James Mills, were mathematicians at Harvard. Charles' domain was logic. He lectured at Hopkins, but never attained a professorship in any institution. He seems not to have been adequately understood by his contemporaries. His solitude, however, enabled him to do more work than he could have done as a professor and to sow seeds nurtured by later thinkers. He developed the idea of Pragmatism taken up twenty years later by William James. The idea of Bertrand Russell's propositional function was familiar to Peirce who called it a *rheme*. Other germi-

nal thoughts had to do with paradoxes. Another concept was that of *Tychism*, a doctrine of evolution having to do with a doubly infinite process in nature, which is not yet fully accepted.

This handsome, well-written portfolio should prove to be a valuable addition to many libraries. C.G.S.

Carleton College, Northfield, Minnesota.

The Masses of the Stars, by Henry Norris Russell and Charlotte E. Moore. 236 pp. (University of Chicago Press. April, 1940. $3.50.)

This monograph presents a valuable summary of the statistical methods developed, mainly by Professor Russell, to obtain the best possible determinations of parallaxes of visual binary systems. In so far as these systems are concerned, the fundamental relations and errors involved in the determinations of dynamical parallaxes and of masses are essentially the same.

The only available means of deriving stellar mass is through gravitational attraction. Since in general the stars are too far apart to have sensible attractions, such determinations can only be made in the case of binary systems, eclipsing, spectroscopic and visual. For eclipsing variables in which the spectroscopic orbits of both components have been calculated, the masses are known without statistical uncertainty. Unfortunately but 33 such cases are known. For spectroscopic binaries the mass function derived from the orbit contains the factor $\sin^3 i$, where i is the unknown inclination, calculable only when the system is also an eclipsing one. Reliable individual masses cannot, therefore, be obtained for these systems.

The gravitational relations in visual systems involve, in addition to the observable internal dimensions and motions, the parallax and the mass. If the parallax is known, the mass may be derived, and *vice versa*. The problem is complicated by the great distances and consequent small parallaxes of all but a few of the stars, with the result that reliable individual mass can be obtained for only about 23 of the nearer visual binaries. For further information recourse must be had to average values in properly selected groups, *i.e.* to statistical methods.

A large part of the first two chapters is taken up with the description of a method of eliminating differences in the distances of the stars and with discussions of the elimination of sources of systematic error and the diminution and evaluation of the effects of accidental errors, problems of considerable statistical interest and difficulty, which will present many points of interest to the student of statistics.

The application of these methods leads to the determination, well confirmed by the reliable individual masses, of a linear correlation between mass and luminosity over a range of 17 absolute magnitudes, which closely parallels Eddington's non-linear relation over the range of magnitude which he covered. While there are deviations from this relation, notably in the case of the white dwarfs, these are not numerous and for the more common spectral types the relation appears to hold for giants and sub-giants as well as for main sequence stars.

Reversing the process and assuming that mass is determined by luminosity, the authors, in Chapters III and IV, develop methods of deriving the parallaxes of binary systems from their internal motions. As aids in following the various refinements introduced, they give the precepts controlling each step in the process, with tables and charts for the interpolation of auxiliary values, which will be very useful in any extension of the work. Chapter V lists the dynamical parallaxes and other essential data for 2529 stars. The mean probable error of the average determination of parallax is about 20 per cent. These data will be extremely useful

in the computation of absolute magnitudes and in studies of stellar distribution and motions.

This monograph presents the most complete and authoritative discussion of stellar masses and dynamical parallaxes now extant. It should be a standard reference for all students of these subjects. R.E.W.

Mt. Wilson Observatory, Pasadena, California.

Die Erde als Planet, by Dr. Karl Stumpff. (J. Springer, Berlin, 1939. 155 pp., price 4.8 marks.)

This little book discusses in popular language the earth as a planet. The discussion, however, is not strictly limited but includes various fields not ordinarily touched in a purely astronomical book. The various chapter titles will give a good idea of the material included. These are: The Earth in the Cosmos; The Earth is a Sphere; The Earth Turns; Position on the Earth's Surface; The Earth Goes Round the Sun; Earth and Moon—a Double System; The Sun Gives Life; The Poles and Earth Magnetism; The Internal Structure of Planet Earth; Earth, Cosmos and Life.

In the chapter on the Earth-Moon System, there are considered the relative sizes and masses of the two bodies, the distance between them, sidereal and synodic months, the Metonic cycle, the Gauss formula for the date of Easter with table of constants and an example, tides in the ocean and atmosphere, and the precession of the equinoxes. This gives an idea of the manner in which the various chapters are handled. There are 50 illustrations in the text. The book can be recommended as a popular exposition of its subject. E.A.F.

Carleton College.

The Evolution of Physics, by A. Einstein and L. Infeld. (The Scientific Book Club, 111 Charing Cross Road, London, W.C. 2. Price 2/6.)

This book, which first appeared in the Cambridge Library of Modern Science series, has for its purpose the sketching "in broad outline the attempts of the human mind to find a connection between the world of ideas and the world of phenomena." With the support of a selection of rudimentary experiments the progress of those attempts is traced from the rather intuitive interpretation of the problem of motion through the rise of the mechanical view, its inability to absorb electrical and optical phenomena into the scheme, the shift in interest to the field and the recognition of relativity, to the quantum view. The lucid exposition of the various problems is made without any mathematics. In addition to describing the evolution of physics to the non-technical reader, the book also should assist in orienting the student so that the main direction of advance is more evident.

Carleton College. R. B. QUINN.

Current Science.—Two copies of the publication issued under this name came to our desk recently. It is published by the American Education Press, Inc., 400 South Front St., Columbus, Ohio. It is intended for pupils of High School grade and touches upon the various physical sciences. The two issues before us emphasize the science of astronomy in that each contains a full two-page map of the northern sky, with detailed description, as it appears in winter and again in the spring. Other numbers feature the other two seasons at the appropriate times. The representation of the sky is especially interesting because the mythical figures of the constellations are included as well as the bright stars. This publication is said to have a circulation of more than 100,000 copies.